

# Brachiopoda of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 848-D





# Brachiopoda of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming

By MACKENZIE GORDON, JR.

THE AMSDEN FORMATION (MISSISSIPPIAN AND PENNSYLVANIAN)  
OF WYOMING

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 848-D

*Descriptions and illustrations of 66 species  
and subspecies of brachiopods, with  
discussion of their distribution*



UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

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# CONTENTS

|  | Page |   | Page |
|--|------|---|------|
| Abstract .....                                   | D1   | Systematic paleontology—Continued                 |      |
| Introduction .....                               | 1    | Genus <i>Orthotetes</i> Fischer de Waldheim ..... | D29  |
| Previous work .....                              | 1    | Genus <i>Derbyia</i> Waagen .....                 | 31   |
| Present study .....                              | 3    | Superfamily Chonetacea .....                      | 32   |
| Acknowledgments .....                            | 4    | Genus <i>Eolissochonetes</i> Hoare .....          | 32   |
| Fossil localities .....                          | 4    | Genus <i>Mesolobus</i> Dunbar and Condra .....    | 35   |
| Composition of the fauna .....                   | 4    | Superfamily Productacea .....                     | 35   |
| Relation to the Mississippian-Pennsylvanian      |      | Genus <i>Scoloconcha</i> Gordon .....             | 35   |
| boundary .....                                   | 4    | Genus <i>Inflatia</i> Muir-Wood and Cooper .....  | 36   |
| Geographic and stratigraphic distribution of the |      | Genus <i>Rugoclostus</i> Easton .....             | 37   |
| brachiopods .....                                | 5    | Genus <i>Diaphragmus</i> Girty .....              | 39   |
| Darwin Sandstone Member .....                    | 5    | Genus <i>Carlinia</i> Gordon .....                | 42   |
| Moffat Trail Limestone Member .....              | 5    | Genus <i>Echinoconchus</i> Weller .....           | 43   |
| Horseshoe Shale Member .....                     | 11   | Genus <i>Flexaria</i> Muir-Wood and Cooper .....  | 44   |
| Ranchester Limestone Member .....                | 13   | Genus <i>Juresania</i> Fredericks .....           | 45   |
| Zonal distribution of the brachiopods .....      | 14   | Genus <i>Antiquatonia</i> Miloradovich .....      | 46   |
| Analysis of faunal relationships .....           | 15   | Genus <i>Ovatia</i> Muir-Wood and Cooper .....    | 49   |
| Inarticulates .....                              | 16   | Genus <i>Linoproductus</i> Chao .....             | 51   |
| Orthids .....                                    | 16   | Superfamily Rhynchonellacea .....                 | 53   |
| Orthotetoids .....                               | 16   | Genus <i>Pugnoides</i> Weller .....               | 53   |
| Chonetids .....                                  | 16   | Superfamily Stenoscismatacea .....                | 54   |
| Productoids .....                                | 16   | Genus <i>Coledium</i> Grant .....                 | 54   |
| Rhynchonelloids .....                            | 16   | Superfamily Athyridacea .....                     | 55   |
| Athyrids .....                                   | 16   | Genus <i>Cleiothyridina</i> Buckman .....         | 55   |
| Spiriferids .....                                | 17   | Genus <i>Composita</i> Brown .....                | 58   |
| Retziids and terebratuloids .....                | 18   | Superfamily Reticulariacea .....                  | 65   |
| Interpretation of faunal succession .....        | 18   | Genus <i>Torynifer</i> Hall and Clarke .....      | 65   |
| Systematic paleontology .....                    | 20   | Superfamily Spiriferacea .....                    | 65   |
| Superfamily Lingulacea .....                     | 20   | Genus <i>Anthracospirifer</i> Lane .....          | 65   |
| Genus <i>Lingula</i> Bruguière .....             | 20   | Genus <i>Brachythyridina</i> Fredericks .....     | 74   |
| Superfamily Discinacea .....                     | 21   | Genus <i>Neospirifer</i> Fredericks .....         | 75   |
| Genus <i>Orbiculoidea</i> d'Orbigny .....        | 21   | Superfamily Spiriferinacea .....                  | 75   |
| Superfamily Enteletacea .....                    | 22   | Genus <i>Reticulariina</i> Fredericks .....       | 75   |
| Genus <i>Schizophoria</i> King .....             | 22   | Superfamily Retziacea .....                       | 77   |
| Genus <i>Rhipidomella</i> Oehlert .....          | 23   | Genus <i>Eumetria</i> Hall .....                  | 77   |
| Superfamily Davidsoniacea .....                  | 24   | Superfamily Dielasmatacea .....                   | 78   |
| Genus <i>Orthotetina</i> Schellwien .....        | 24   | Genus <i>Girtyella</i> Weller .....               | 78   |
| Genus <i>Pulsia</i> Ivanov .....                 | 25   | Incertae sedis .....                              | 78   |
| Genus <i>Schuchertella</i> Girty .....           | 28   | Genus <i>Selenella</i> Hall and Clarke .....      | 78   |
|  |      | References cited .....                            | 79   |
|  |      | Index .....                                       | 83   |

## ILLUSTRATIONS

[Plates 1–13 follow index]

- PLATE    1. *Lingula*, *Orbiculoidea*, *Schizophoria*, *Rhipidomella*, *Mesolobus*, *Eolissochonetes*, *Schuchertella*, and *Orthotetes*.
2. *Orthotetina*, *Pulsia*, *Schuchertella*, *Orthotetes*, and *Derbyia*.
3. *Inflatia*, *Rugoclostus*, *Echinoconchus*, *Scoloconcha*, *Juresania*, and *Flexaria*.

|       |  |
|-------|--|
| PLATE | 4. <i>Diaphragmus</i> and <i>Carlinia</i> .  |
|       | 5. <i>Antiquatonia</i> and <i>Linoproductus</i> .  |
|       | 6. <i>Ovatia</i> and <i>Linoproductus</i> .  |
|       | 7. <i>Coledium</i> , <i>Pugnoides</i> , and <i>Cleiothyridina</i> .  |
|       | 8-10. <i>Composita</i> .   |
|       | 11, 12. <i>Anthracospirifer</i> .  |
|       | 13. <i>Anthracospirifer</i> , <i>Brachythyridina</i> , <i>Neospirifer</i> , <i>Eumetria</i> , <i>Girtyella</i> , <i>Reticulariina</i> , and <i>Torynifer</i> . |

|        |   |      |
|--------|---|------|
|        |   | Page |
| FIGURE | 1. Distribution of <i>Composita</i> in the Amsden Formation -----       | D18  |
|        | 2. Distribution of <i>Anthracospirifer</i> in the Amsden Formation ---- | 19   |
|        | 3. Profiles of orthotetoid brachiopods in the Amsden Formation ---      | 25   |

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## TABLES

---

|       |  |      |
|-------|--|------|
|       |  | Page |
| TABLE | 1. Taxonomic relationships and relative abundance of brachiopods in the Amsden Formation of Wyoming -----      | D5   |
|       | 2. Brachiopod fauna of the Amsden Formation of Wyoming ----  | 6    |
|       | 3. Checklist of brachiopod collections -----   | 9    |
|       | 4. Stratigraphic distribution of Amsden brachiopods equated with foraminifer zones and coral occurrences ----- | 15   |
|       | 5. Coral and brachiopod zones of the Amsden Formation of Wyoming -----   | 15   |

BRACHIOPODA OF THE AMSDEN FORMATION  
(MISSISSIPPIAN AND PENNSYLVANIAN) OF WYOMING

By MACKENZIE GORDON, JR.

ABSTRACT

Brachiopods are the most numerous fossils and biostratigraphically the most useful of the various phyla represented in the megafauna of the Amsden Formation of Wyoming. The present study is based on more than 4,900 specimens from the collections of the U.S. Geological Survey, U.S. National Museum, University of Missouri, University of Wyoming, and Yale University Peabody Museum. The study has resulted in the recognition of 66 species and subspecies of brachiopods belonging in 34 genera. These species are described and illustrated in this report.

Some of the brachiopods are new, and new names are herein proposed for 19 of them. These are *Pulsia delira*, *Orthotetes kaskaskiensis* *bransonorum*, *Inflatia lovei*, *Rugoclostus williamsi*, *Diaphragmus nivosus*, *Antiquatonia blackwelderi*, *Ovatia muralis*, *Linoproductus eastoni*, *Coledium fragum*, *Cleiothyridina atrypoides* *saginata*, *C. hirsuta darwinensis*, *Composita sigma*, *C. poposiensis*, *Anthracospirifer curvilateralis brutus*, *A. rawlinsensis*, *A. shawi shawi*, *A. s. exoletus*, *A. welleri lincolnsensis*, and *Brachythyridina washakiensis*. Lectotypes are designated for *Orthotetina amsdenensis* (Branson and Greger), *Anthracospirifer welleri* (Branson and Greger), *Reticulariina browni* (Branson and Greger), and *Composita blackwelderi* C. Branson [= *Reticulariina browni* (Branson and Greger)].

Study of the stratigraphic distribution of the brachiopods shows that 41 of the taxa are restricted to the Mississippian part of the Amsden, 20 occur only in the Pennsylvanian part, and 5 are known to cross the Mississippian-Pennsylvanian boundary.

The brachiopod distribution demonstrates that the plane of the Mississippian-Pennsylvanian boundary, as approximated by the biostratigraphic distribution of the Amsden faunas, is at an angle to and, in fact, crosses the lithologic boundaries separating the members of this formation. In western Wyoming the Mississippian-Pennsylvanian boundary, as delimited by the brachiopods, locally occurs rather high in the Ranchester Limestone Member, the uppermost of the members of the Amsden; in east-central Wyoming the same boundary is somewhere below the base of the Horse-shoe Shale Member, which underlies the Ranchester. Intermediate sections show that the west-to-east transgression of the Amsden Formation was gradual.

Brachiopod and, in part, coral assemblages permit the subdivision of the Amsden rocks into several faunal zones. The

earliest of these, restricted to western Wyoming, is the *Caninia* coral zone in which *Anthracospirifer curvilateralis brutus* n. subsp. is perhaps the most characteristic brachiopod. Overlying the *Caninia* Zone is the *Anthracospirifer shawi-welleri* Zone, predominantly a brachiopod zone, largely of rather distinctive anthracospirifers and compositas, which includes the youngest Mississippian rocks in this region. In central Wyoming this zone is subdivided into two subzones, a lower *Carlinia amsdeniana* Subzone and an upper *Composita poposiensis* Subzone.

The lowest Pennsylvanian zone in western Wyoming is the *Antiquatonia blackwelderi* Zone; it is early Morrowan in age. The *Neokoninckophyllum hamatilis* Zone, named for a coral but consisting mainly of brachiopods, is recognized in the Rawlins hills region in southeastern Wyoming and is probably late Morrowan in age. The highest faunal zone, characterized by *Mesolobus* sp. and not given a formal name, occurs also in the Rawlins hills and is Atokan in age.

INTRODUCTION

Brachiopods constitute the major element of the Amsden megafauna; 66 species and subspecies have been recognized, belonging in 34 genera. These are widely but sporadically distributed in limestone, sandstone, and ferruginous siltstone beds throughout the formation, with the sole exception of the Darwin Sandstone Member, the basal transgressive unit of the formation.

Most of the brachiopod genera in the Amsden are those that occur commonly elsewhere in the United States in rocks of the same age. Two exceptions to this are the orthotetoid genus *Pulsia* and the spiriferoid genus *Brachythyridina*, both of them originally described from Upper Carboniferous beds in the Moscow basin, U.S.S.R., and now recognized in the United States for the first time. *Pulsia* is represented in the Amsden Formation by two species.

PREVIOUS WORK

Ever since Darton (1906, p. 31-34) first named and described the Amsden Formation, it has been

known to contain Pennsylvania brachiopods and considered to include beds of both Mississippian and Pennsylvania age. Although the Mississippian coral upon which Darton based the age of part of the Amsden actually came from the Madison Limestone, many Mississippian fossils have since been found in the formation, including most of the brachiopods.

The Amsden megafauna is known principally from faunal lists made by a variety of paleontologists; these lists have appeared almost exclusively in papers dealing with the physical stratigraphy of this formation. Only four papers can be said to have been oriented toward a study of the paleontology of this formation.

The first taxonomic work on the fossils of the Amsden Formation of Wyoming was by E. B. Branson and D. K. Greger (1918). In this paper, 14 brachiopods that came from the middle part of the formation in the Wind River Range were described and illustrated. These are listed below, together with their names as classified in the present paper. Omitted from consideration are three other brachiopod species, *Spirifer shoshonensis* Branson and Greger, *Tetracamera subcuneata* (Hall), and *Chonetes chesterensis* Weller, which actually were collected from what is now known as the Bull Ridge Member of the Madison Limestone (Sando, 1968, p. 1855) and are pre-Amsden in age.

| Branson and Greger (1918)                               | This paper  |
|---|---|
| <i>Orbiculoidea wyomingensis</i><br>Branson and Greger. | <i>Orbiculoidea wyomingensis</i><br>Branson and Greger.                                 |
| <i>Orthotetes kaskaskiensis</i><br>(McChesney).         | <i>Orthotetes kaskaskiensis</i><br><i>bransonorum</i> n. subsp.                         |
| <i>Diaphragmus phillipsi</i><br>(Norwood and Pratten).  | <i>Carlinia amsdeniana</i> Gordon.  |
| <i>Pustula genevievensis</i><br>(Weller).               | <i>Flexaria</i> sp.   |
| <i>Meekella amsdenensis</i><br>Branson and Greger.      | <i>Orthotetina amsdenensis</i><br>(Branson and Greger).                                 |
| <i>Spiriferina browni</i><br>Branson and Greger.        | <i>Reticulariina browni</i><br>(Branson and Greger).                                    |
| <i>Spirifer pellaensis</i> (Weller)                     | <i>Anthracospirifer shawi shawi</i><br>n. subsp. and <i>A. s. exoletus</i><br>n. subsp. |
| <i>S. welleri</i> Branson and<br>Greger.                | <i>A. welleri welleri</i> (Branson<br>and Greger).                                      |
| <i>Martinia</i> n. sp. -----                            | <i>Composita sigma</i> n. sp.?  |
| <i>Pugnoides ottumwa</i> (White)                        | <i>Pugnoides quinqueplecis</i><br>Easton.   |
| <i>Composita trinuclea</i> (Hall)                       | <i>Composita poposiensis</i> n. sp.   |
| <i>Eumetria verneuiliana</i> (Hall)                     | <i>Eumetria sulcata</i> Burk.   |
| <i>Cleiothyridina hirsuta</i> (Hall)                    | <i>Cleiothyridina</i> aff. <i>C. elegans</i><br>Girty.                                  |
| <i>Schizophoria swallowi</i> (Hall)                     | ? <i>Schizophoria depressa</i> Easton.  |

Branson and Greger (1918, p. 312) concluded that the fauna is Late Mississippian in age and should be correlated with that of the St. Genevieve Lime-

stone (upper Meramecian) of the Mississippi River valley.

Eight Amsden brachiopods, six of them regarded as new, were described and figured by C. C. Branson (1937, p. 655-657, pl. 89). They are from the same general area in the Wind River Range as those of Branson and Greger. Four of these new species were based on tiny juvenile shells, at least part of which came from the residue of washed material from which Morey (1935) described the ostracodes. These juveniles are marked with an asterisk (\*) in the list below. They have been identified as young specimens of the species shown in the right-hand column.

| C. C. Branson (1937)  | This paper  |
|---|---|
| <i>Orbiculoidea wyomingensis</i><br>Branson and Greger.     | <i>Orbiculoidea wyomingensis</i><br>Branson and Greger.                   |
| * <i>Rhipidomella gregeri</i> C.<br>Branson.                | <i>Anthracospirifer welleri well-</i><br><i>eri</i> (Branson and Greger). |
| * <i>Rhipidomella gregeri</i> C.<br>Branson (one paratype). | <i>Girtyella</i> cf. <i>G. indianensis</i><br>Girty.                      |
| * <i>Streptorhynchus poposiensis</i><br>C. Branson.         | <i>Schuchertella poposiensis</i><br>(C. Branson).                         |
| <i>Chonetes suttoni</i> C. Branson--                        | Species inquirenda.   |
| <i>Linoproductus croneisi</i><br>C. Branson.                | <i>Ovatia croneisi</i> (C. Branson).                                      |
| * <i>Selenella? walteri</i> C.<br>Branson (holotype).       | Species inquirenda.   |
| * <i>Selenella? walteri</i> C.<br>Branson (two paratypes).  | <i>Pugnoides quinqueplecis</i><br>Easton.                                 |
| ? <i>Girtyella indianensis</i><br>(Girty).                  | <i>Girtyella</i> cf. <i>G. indianensis</i><br>(Girty).                    |
| * <i>Composita blackwelderi</i> C.<br>Branson.              | <i>Reticulariina browni</i><br>(Branson and Greger).                      |

C. C. Branson (1937, p. 650-653), like E. B. Branson and Greger before him, regarded this fauna as St. Genevieve in age, but he included it in his Sacajawea Formation (Branson, 1936), which he had separated from the main part of the Amsden Formation because, he pointed out, other geologists had recognized fossils of Pennsylvanian age at several localities in the upper beds of the Amsden. Branson's type section of the Sacajawea Formation on Bull Lake Creek, however, consisted entirely of limestone belonging in the upper part of the Madison Limestone and is early Meramecian in age. These beds have been renamed Bull Ridge Member of the Madison Limestone by Sando.

Burk (1954) described and figured brachiopods collected by C. A. Biggs from the Amsden of the Wind River Range. Biggs's specimens came from Beaver Creek, South Pass, Cherry Creek, and Horse Creek, all in Fremont County. These fossils are from the Horseshoe Shale Member of the Amsden Formation. Burk's identifications are listed below with the identifications of the same fossils as revised by

the present study. Burk (1954, p. 5) concluded that all the fossiliferous beds of the Amsden Formation are Pennsylvanian in age. This conclusion was foregone, seeing that he identified his fossils largely as Pennsylvanian species, including some of the same forms that E. B. Branson and Greger and C. C. Branson had previously determined as Mississippian species.

| C. A. Burk (1954)  | This paper   |
|--|--|
| <i>Lingulodiscina</i> sp -----                               | <i>Orbiculoidea</i> sp. A.   |
| <i>Orthotetes?</i> sp -----                                  | <i>Orthotetes kaskaskiensis</i><br><i>bransonorum</i> n. subsp.?   |
| <i>Dictyoclostus portlockianus</i><br>(Norwood and Pratten). | <i>Inflatia lovei</i> n. sp.   |
| <i>Linoproductus prattenianus</i><br>(Norwood and Pratten).  | <i>Ovatia muralis</i> n. sp.?  |
| <i>Cancrinella boonensis</i><br>(Swallow).                   | <i>Ovatia croneisi</i> (C. Branson).   |
| <i>Marginifera muricata</i><br>Dunbar and Condra.            | <i>Carlinia amsdeniana</i> Gordon.   |
| <i>Marginifera</i> sp -----                                  | <i>Productoid</i> , gen. and sp. indet.  |
| <i>Spirifer opimus</i> Hall -----                            | <i>Anthracospirifer shawi</i><br><i>exoletus</i> n. subsp.   |
| <i>Spirifer opimus</i> Hall (one<br>specimen).               | <i>Anthracospirifer welleri welleri</i><br>(Branson and Greger).   |
| <i>Spirifer</i> sp -----                                     | <i>Anthracospirifer shawi</i><br><i>exoletus</i> n. subsp.   |
| <i>Composita subtilita</i> var.<br><i>subtilita</i> (Hall).  | <i>Composita poposiensis</i> n. sp.<br>and <i>C. sulcata</i> Weller.   |
| <i>Composita subtilita</i> var.<br><i>ovata</i> Mather.      | <i>Composita sulcata</i> Weller.<br>and <i>C. poposiensis</i> n. sp.   |
| <i>Composita subtilita</i> var.<br><i>trinuclea</i> (Hall).  | <i>Composita poposiensis</i> n. sp.  |
| <i>Composita</i> sp -----                                    | <i>Composita</i> sp.   |
| <i>Cleiothyridina</i> sp -----                               | <i>Composita poposiensis</i> n. sp.<br>(juvenile) and <i>Cleiothyridina</i><br><i>hirsuta darwinensis</i> n.<br>subsp. |
| <i>Eumetria sulcata</i> Burk -----                           | <i>Eumetria sulcata</i> Burk   |
| <i>Wellerella osagensis</i><br>(Swallow).                    | <i>Pugnoides quinqueplecis</i><br>Easton.  |

The following year, Shaw and Bell (1955) reported on six collections that Bell had collected in situ by trenching the section at Cherry Creek. They listed the species from these collections on a chart showing their stratigraphic occurrences and concluded that Mississippian fossils are present as much as 48 feet above the base of the formation, and Pennsylvanian fossils are present 63 feet above the base. No descriptive taxonomic work accompanied this study.

Shaw (1955) also restudied Burk's fossils and those of other students at the University of Wyoming and concluded that a lower *Spirifer welleri* fauna of Mississippian age could be recognized in several sections, as well as a higher *Spirifer "opimus"* fauna of Pennsylvanian age.

A recent descriptive work with a direct bearing

on the faunas of the Amsden Formation is the study by Easton (1962) of the Carboniferous formations and faunas of central Montana. A few fossils that he described from the Heath Formation of Montana have been recognized during the present study in the Mississippian part of the Amsden Formation of Wyoming, and several species from the Cameron Creek Member of the Tyler Formation and Alaska Bench Limestone of Montana have turned up in the Pennsylvanian part of the Amsden. Easton (1962, p. 14-16) believed all three of these Montana stratigraphic units to be Mississippian in age. More recently, however, Maughan and Roberts (1967) have insisted on a Pennsylvanian age for the upper two units.

After this manuscript was completed, an excellent work on Pennsylvanian brachiopods was published by Sutherland and Harlow (1974, Pennsylvanian brachiopods and biostratigraphy in southern Sangre de Cristo Mountains, New Mexico: New Mexico Bur. Mines and Mineral Resources, Mem. 27, 1973 p., 18 pls., 51 figs., 30 photos). Their designation of a lectotype for *Spiriferina spinosa* var. *campestris* White has led me to the present treatment of *S. campestris* and *S. gonionota* Meek as different species belonging in different genera, in the discussion of *Reticularina browni* (Branson and Greger) in this report. Sutherland and Harlow's paper, however, is not included in the synonymies.

#### PRESENT STUDY

Our biostratigraphic investigation of the Amsden Formation of Wyoming depends largely upon brachiopods and foraminifers; the need, therefore, for a comprehensive taxonomic study of the brachiopods is basic. The brachiopods seem to occur somewhat more widely than the foraminifers, which were not found, for example, in the Horseshoe Shale Member of this formation in the Wind River Range, the area where brachiopods are perhaps the most abundant.

My interest in the biostratigraphy of the Amsden Formation stems from various discussions with the late J. S. Williams, who was greatly concerned with the stratigraphic problems connected with this formation in western Wyoming; also with W. H. Easton who, during the time he shared an office with me in Washington, D.C., was engaged in writing his report on the formations and faunas of similar age in central Montana (Easton, 1962). Field studies during the early summer of 1955 with Easton, L. S. Gardner, P. E., Cloud, Jr., and R. J. Ross, Jr., afforded the opportunity to study some of the sections and collect fossils from them.

The present study has been largely one of previously collected material. An attempt has been made to examine all the fossils upon which previous taxonomic work and definitive age determinations were based. Material has been borrowed from several universities and from the U.S. National Museum.

The Amsden brachiopod fauna considered in the present report includes about three times the number of taxa that have been described and illustrated by earlier authors. All previously published material has been restudied and reevaluated, including many specimens upon which earlier faunal lists were based. As every one of the previously described taxa is now known to have come from the Mississippian parts of the formation, the Pennsylvanian components of the fauna are here described and illustrated for the first time. Some of the species recorded from Wyoming for the first time are the same as those from equivalent rocks in central Montana. Where applicable, the brachiopods described by Easton (1962) from the Carboniferous formations in that region have also been restudied.

The more than 4,900 brachiopods studied represent the labors of many collectors in Wyoming. They include W. G. Bell, C. A. Biggs, Eliot Blackwelder, C. C. Branson, E. B. Branson, N. H. Brown, C. A. Burk, P. E. Cloud, Jr., N. H. Darton, C. H. Dobbin, J. T. Dutro, Jr., Mackenzie Gordon, Jr., D. K. Greger, L. G. Henbest, I. A. Keyte, E. M. Kindle, W. T. Lee, J. D. Love, P. S. Morey, W. W. Rubey, W. J. Sando, and J. S. Williams. The 66 taxa discussed in this paper probably represent a very high percentage of the total brachiopod fauna of the Amsden Formation.

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#### FOSSIL LOCALITIES

For the purpose of simplification, the collections studied during our investigations of the Amsden Formation and its faunas have been given numbers from 1 to 160. Material is included from U.S. Geological Survey (USGS) and U.S. National Museum (USNM) collections and collections in the University of Wyoming (UW), University of Missouri (UM), and Yale University's Peabody Museum (YPM). The permanent numbers of these collections, locality descriptions, and complete lists of identified fossils are given in the first report in this series on the Amsden Formation (Sando and others, 1975). A checklist of the brachiopod collections is given in table 3.

#### COMPOSITION OF THE FAUNA

The brachiopod fauna of the Amsden Formation, which includes beds ranging from middle Chesterian to Atokan in age, is made up of several different subfaunas or faunules. Their overall composition is shown in table 1, which lists the families and genera of Amsden brachiopods, the number of specimens belonging to each of them, and the percentage of the total brachiopod fauna studied that each represents. The Mississippian and Pennsylvania specimens have been separated in the table; the totals for each genus are given in the right-hand pair of columns. The Mississippian specimens outnumber the Pennsylvanian about five to one. Numerically, the *compositas* and *anthracospirifers* are the most abundant, making up slightly more than two-thirds of the fauna; some *productoid* and *orthotetoid* brachiopods are also present. All four of these groups have proven useful biostratigraphically in subdividing the Amsden into faunal zones.

The brachiopod species are listed in table 2. This table gives their occurrence in each of the 110 collections of Amsden brachiopods used in this study. A checklist of the collections is given in table 3.

#### RELATION TO THE MISSISSIPPIAN-PENNSYLVANIAN BOUNDARY

None of the species of the four groups mentioned above crosses the Mississippian-Pennsylvanian boundary. In fact, of the 66 brachiopod species and subspecies described in the systematic part of this report, only 5 have been recorded both in Mississippian and Pennsylvanian rocks. These are *Lingula* cf. *L. carbonaria* Shumard, *Schizophoria depressa* Easton, *S. aff. S. texana* Girty, *Eolissochonetes pseudoliratus* (Easton), and *Pugnoides quinqueplecis* Easton. The last two begin near the top of the Mississippian section, where their Mississippian age is indicated by associated species. *Eolissochonetes*



TABLE 1.—Taxonomic relationships and relative abundance of brachiopods in the Amsden Formation of Wyoming

| Family           | Genus                   | Mississippian specimens |   | Pennsylvanian specimens |   | Totals |   |
|------------------|-------------------------|-------------------------|---|-------------------------|---|--------|---|
|                  |                         | Number                  | Percent of total identifiable brachiopods | Number                  | Percent of total identifiable brachiopods | Number | Percent of total identifiable brachiopods |
| Lingulidae       | <i>Lingula</i>          | 5                       | 0.10                                      | 3                       | 0.06                                      | 8      | 0.16                                      |
| Discinidae       | <i>Orbiculoidea</i>     | 8                       | .16                                       | 2                       | .04                                       | 10     | .20                                       |
| Entletidae       | <i>Schizophoria</i>     | 8                       | .16                                       | 53                      | 1.07                                      | 61     | 1.23                                      |
| Rhipidomellidae  | <i>Rhipidomella</i>     | ---                     | ---                                       | 30                      | .61                                       | 30     | .61                                       |
| Meekellidae      | <i>Orthotetina</i>      | 8                       | .16                                       | ---                     | ---                                       | 8      | .16                                       |
|                  | <i>Pulsia</i>           | 3                       | .06                                       | 4                       | .08                                       | 7      | .14                                       |
| Schuchertellidae | <i>Schuchertella</i>    | 11                      | .22                                       | ---                     | ---                                       | 11     | .22                                       |
| Orthotetidae     | <i>Orthotetes</i>       | 50                      | 1.01                                      | 41                      | .83                                       | 91     | 1.84                                      |
|                  | <i>Derbyia</i>          | ---                     | ---                                       | 19                      | .39                                       | 19     | .39                                       |
| Chonetidae       | <i>Eolissochonetes</i>  | 122                     | 2.47                                      | 127                     | 2.57                                      | 249    | 5.04                                      |
|                  | <i>Mesolobus</i>        | ---                     | ---                                       | 6                       | .12                                       | 6      | .12                                       |
| Overtoniidae     | <i>Scolonconcha</i>     | ---                     | ---                                       | 2                       | .04                                       | 2      | .04                                       |
| Marginiferidae   | <i>Inflatia</i>         | 103                     | 2.09                                      | ---                     | ---                                       | 103    | 2.09                                      |
|                  | <i>Rugoclostus</i>      | ---                     | ---                                       | 18                      | .36                                       | 18     | .36                                       |
| Productidae      | <i>Diaphragmus</i>      | 89                      | 1.80                                      | ---                     | ---                                       | 89     | 1.80                                      |
|                  | <i>Carlina</i>          | 103                     | 2.09                                      | ---                     | ---                                       | 103    | 2.09                                      |
| Echinoconchidae  | <i>Echinoconchus</i>    | ---                     | ---                                       | 11                      | .22                                       | 11     | .22                                       |
| Buxtoniidae      | <i>Flexaria</i>         | 2                       | .04                                       | ---                     | ---                                       | 2      | .04                                       |
|                  | <i>Juresania</i>        | ---                     | ---                                       | 7                       | .14                                       | 7      | .14                                       |
| Dictyoclostidae  | <i>Antiquatonia</i>     | 4                       | .08                                       | 103                     | 2.09                                      | 107    | 2.17                                      |
| Linoproductidae  | <i>Ovatia</i>           | 37                      | .75                                       | ---                     | ---                                       | 37     | .75                                       |
|                  | <i>Linoproductus</i>    | ---                     | ---                                       | 103                     | 2.09                                      | 103    | 2.09                                      |
| Stenosismatidae  | <i>Coledium</i>         | 10                      | .20                                       | ---                     | ---                                       | 10     | .20                                       |
| ?                | <i>Pugnoides</i>        | 263                     | 5.33                                      | ---                     | ---                                       | 263    | 5.33                                      |
| Athyrididae      | <i>Cleiothyridina</i>   | 26                      | .53                                       | 6                       | .12                                       | 32     | .65                                       |
|                  | <i>Composita</i>        | 2,203                   | 44.64                                     | 177                     | 3.59                                      | 2,380  | 48.23                                     |
| Elythidae        | <i>Torynifer</i>        | 3                       | .06                                       | ---                     | ---                                       | 3      | .06                                       |
| Spiriferidae     | <i>Anthracospirifer</i> | 931                     | 18.87                                     | 55                      | 1.11                                      | 986    | 19.98                                     |
|                  | <i>Brachythyridina</i>  | 6                       | .12                                       | ---                     | ---                                       | 6      | .12                                       |
|                  | <i>Neospirifer</i>      | 1                       | .02                                       | ---                     | ---                                       | 1      | .02                                       |
| Spiriferinidae   | <i>Reticularina</i>     | 93                      | 1.88                                      | ---                     | ---                                       | 93     | 1.88                                      |
| Retziidae        | <i>Eumetria</i>         | 75                      | 1.52                                      | ---                     | ---                                       | 75     | 1.52                                      |
| Cranaenidae      | <i>Girtyella</i>        | 3                       | .06                                       | ---                     | ---                                       | 3      | .06                                       |
| ?                | <i>Selenella?</i>       | 1                       | .02                                       | ---                     | ---                                       | 1      | .02                                       |
| Total            |                         | 4,168                   | 84.44                                     | 767                     | 15.53                                     | 4,935  | 99.97                                     |

*pseudoliratus* occurs at one locality in association with Foramanifera of Mamet's Zone 19.

Of the other 61 taxa described in this report, 41 are restricted to the Mississippian and 20 to the Pennsylvanian.

#### GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION OF THE BRACHIOPODS

Because the Amsden Formation is transgressive and contains several different facies, it is difficult, if not impossible, to discuss at the same time the distribution of the brachiopods in terms of the rocks (distribution in the formation and its members) and in terms of geologic time (distribution in time-rock units such as system and series). Evidence derived from both the brachiopods and foraminifers has shown, for example, that the Horseshoe Shale Member is middle to late Chesterian (Late Mississippian) age in western Wyoming and late Morrowan (Early Pennsylvanian) age in the Rawlins uplift in south-central Wyoming. The overlying Ranchester Limestone Member is very late Chesterian and early Morrowan age in western Wyoming and late Morrowan and Atokan age in the Rawlins hills.

To approach this part of the discussion with a

sense of order, let us first consider the distribution of the brachiopod assemblages in each member by counties, generally moving in a direction from west to east (actually west to north to east to southeast), to obtain a roughly chronological sequence from older to younger beds. Following this we will review the brachiopod biostratigraphy of the Amsden Formation from a zonal and time-rock viewpoint.

#### DARWIN SANDSTONE MEMBER

No brachiopods or any other fossils of Amsden Age have been found in the Darwin Sandstone Member. Brachiopods and conodonts were collected from limestone lenses within the lower part of the sandstone section at Little Tongue River on the northeast flank of the Bighorn Mountains, Sheridan County, but these were determined as having the same age as the Bull Ridge Member of the Madison Limestone and therefore are not considered part of the Amsden fauna. This occurrence is discussed by Sando, Gordon, and Dutro (1975).

#### MOFFAT TRAIL LIMESTONE MEMBER

The Moffat Trail Limestone Member, proposed and described by Sando Gordon and Dutro (1975), is a lateral equivalent of the Horseshoe Shale Mem-



BRACHIOPODA OF THE AMSDEN FORMATION

D7

18

# THE AMSDEN FORMATION (MISSISSIPPIAN AND PENNSYLVANIAN) OF WYOMING

TABLE 3.—*Checklist of brachiopod collections*

| Collection No. in report | Permanent institutional locality No. | Name of locality               | Mountain range     | County   | Location  | Member      |
|--------------------------|--------------------------------------|--------------------------------|--------------------|----------|---|-------------|
| 1 -----                  | USGS 5441-PC                         | Cherokee Spring                | Rawlins hills      | Carbon   | Probably in SW $\frac{1}{4}$ sec. 11, T. 21 N., R. 88 W.                  | Horseshoe.  |
| 2 -----                  | USGS 8071-PC                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 3 -----                  | USGS 3139-PC                         | ---do---                       | ---do---           | ---do--- | NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 11, T. 21 N., R. 88 W.             | Do.         |
| 4 -----                  | USGS 3140-PC                         | Cherokee Peak                  | ---do---           | ---do--- | NW $\frac{1}{4}$ sec. 10, T. 21 N., R. 88 W.                              | Do.         |
| 5 -----                  | USGS 3885-PC                         | ---do---                       | ---do---           | ---do--- | SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 10, T. 21 N., R. 88 W.             | Do.         |
| 6 -----                  | USGS 3843-PC                         | Rawlins US 287                 | ---do---           | ---do--- | Probably NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 32, T. 22 N., R. 87 W.    | Ranchester. |
| 7 -----                  | USGS 21727-PC                        | Meadow Ranch                   | ---do---           | ---do--- | SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 22 N., R. 88 W.             | Horseshoe.  |
| 8 -----                  | USGS 21728-PC                        | ---do---                       | ---do---           | ---do--- | SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 22 N., R. 88 W.             | Do.         |
| 9 -----                  | Shaw collection                      | ---do---                       | ---do---           | ---do--- | NE $\frac{1}{4}$ sec. 25, T. 22 N., R. 88 W.                              | Do.         |
| 13 -----                 | USGS 21729-PC                        | ---do---                       | ---do---           | ---do--- | SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 22 N., R. 88 W.             | Ranchester. |
| 14 -----                 | USGS 21725-PC                        | Buck Spring                    | ---do---           | ---do--- | NW $\frac{1}{4}$ sec. 33, T. 23 N., R. 88 W.                              | Do.         |
| 15 -----                 | USGS 5864-PC                         | Belle Springs                  | ---do---           | ---do--- | SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 29, T. 23 N., R. 88 W.             | Do.         |
| 19 -----                 | UW 2997/6A                           | Beaver Creek                   | Wind River Range.  | Fremont  | NW $\frac{1}{4}$ sec. 6, T. 29 N., R. 97 W.                               | Horseshoe.  |
| 21 -----                 | UW 3099/9B                           | South Pass                     | ---do---           | ---do--- | Center sec. 9, T. 30 N., R. 99 W.   | Do.         |
| 22 -----                 | UW 3099/9A                           | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 26a -----                | USGS 19284-PC                        | Amsden Hill                    | ---do---           | ---do--- | Probably SW $\frac{1}{4}$ sec. 32, T. 31 N., R. 99 W.                     | Do.         |
| 26b -----                | USNM 487                             | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 27 -----                 | USGS 19283-PC                        | Cherry Creek                   | ---do---           | ---do--- | Probably sec. 30, T. 31 N., R. 99 W.                                      | Do.         |
| 28 -----                 | UW 3199/19B2                         | ---do---                       | ---do---           | ---do--- | SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 19, T. 31 N., R. 99 W.             | Do.         |
| 29 -----                 | UW 3199/19B3                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 30 -----                 | UW 3199/19B4                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 31 -----                 | UW 3199/19B5                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 32 -----                 | UW 3199/19B6                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 34 -----                 | UW 3199/19B8                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 35 -----                 | UW 3199/19A                          | ---do---                       | ---do---           | ---do--- | NW $\frac{1}{4}$ sec. 19, T. 31 N., R. 99 W.                              | Do.         |
| 36a -----                | UM numbers                           | ---do---                       | ---do---           | ---do--- | Sec. 19, T. 31 N., R. 99 W.   | Do.         |
| 36b -----                | UM numbers                           | Cherry Creek?                  | ---do---           | ---do--- | Same but labeled sec. 31, T. 19 N., R. 99 W.                              | Do.         |
| 36c -----                | UM numbers                           | Near Lander                    | ---do---           | ---do--- | Exact locality not known  | Do.         |
| 36d -----                | UM numbers                           | Little Popo Agie River.        | ---do---           | ---do--- | ---do---  | Do.         |
| 36e -----                | USNM 487A                            | Cherry Creek                   | ---do---           | ---do--- | Sec. 19, T. 31 N., R. 99 W.   | Do.         |
| 38 -----                 | USGS 16397-PC                        | Little Popo Agie Canyon.       | ---do---           | ---do--- | NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 19, T. 31 N., R. 99 W.             | Do.         |
| 39 -----                 | USGS 14025-PC                        | ---do---                       | ---do---           | ---do--- | SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 13, T. 31 N., R. 100 W.            | Do.         |
| 41 -----                 | USGS 19156-PC                        | Soda Creek                     | Washakie Range.    | Teton    | Sec. 5, T. 45 N., R. 110 W.   | Do.         |
| 42 -----                 | UW 43106/19A                         | Horse Creek                    | ---do---           | Fremont  | SW $\frac{1}{4}$ sec. 19, T. 43 N., R. 106 W.                             | Do.         |
| 43 -----                 | UW 43106/19B                         | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 44 -----                 | YPM 5154A-T, 20103, 20106            | ---do---                       | ---do---           | ---do--- | Sec. 19, T. 43 N., R. 106 N.  | Do.         |
| 45 -----                 | USGS 21719-PC                        | Livingston Ranch.              | ---do---           | ---do--- | SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 43 N., R. 106 W.            | Do.         |
| 46 -----                 | USGS 16197-PC                        | Wiggins Fork                   | ---do---           | ---do--- | SW $\frac{1}{4}$ sec. 7, T. 42 N., R. 105 W.                              | Do.         |
| 47 -----                 | USGS 16198-PC                        | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 48 -----                 | YPM 20101-20110                      | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |
| 52 -----                 | USGS 2461-PC, 2461A-PC               | North Fork, Crazy Woman Creek. | Bighorn Mountains. | Johnson  | SE $\frac{1}{4}$ sec. 28, or NE $\frac{1}{4}$ sec. 33, T. 49 N., R. 83 W. | Ranchester. |
| 53 -----                 | USGS 19241-PC                        | South Fork, Rock Creek.        | ---do---           | ---do--- | SW $\frac{1}{4}$ sec. 25, T. 52 N., R. 84 W.                              | Horseshoe.  |
| 54 -----                 | USGS 19240-PC                        | ---do---                       | ---do---           | ---do--- | ---do---  | Do.         |

TABLE 3.—*Checklist of brachiopod collections—Continued*

| Collection No. in report | Permanent institutional locality No. | Name of locality    | Mountain range     | County            | Location   | Member        |
|--------------------------|--------------------------------------|---------------------|--------------------|-------------------|--|---------------|
| 63                       | USGS 22206-PC                        | Amsden Creek        | Bighorn Mountains. | Sheridan          | SW $\frac{1}{4}$ sec. 34, T. 57 N., R. 87 W.                   | Ranchester.   |
| 67                       | USGS 16215-PC                        | do                  | do                 | do                | SW $\frac{1}{4}$ sec. 34, T. 57 N., R. 87 W.                   | Do.           |
| 68                       | USGS 22204-PC                        | do                  | do                 | do                | SE $\frac{1}{4}$ sec. 32, T. 57 N., R. 87 W.                   | Do.           |
| 69                       | USGS 16216-PC                        | Devils Canyon       | do                 | Carbon (Montana). | W $\frac{1}{2}$ sec. 35, T. 9 S., R. 28 E.                     | Horseshoe.    |
| 72                       | USGS 6957-PC                         | Bear Creek          | Salt River Range.  | Lincoln           | NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 27, T. 33 N., R. 117 W. | Moffat Trail. |
| 73                       | USGS 6960-PC                         | Moffat Trail        | do                 | do                | NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T. 33 N., R. 117 W.  | Do.           |
| 75                       | USGS 22986-PC                        | do                  | do                 | do                | do   | Do.           |
| 76                       | USGS 22987-PC                        | do                  | do                 | do                | do   | Do.           |
| 77                       | USGS 6960A-PC                        | do                  | do                 | do                | do   | Do.           |
| 78                       | USGS 6960B-PC                        | do                  | do                 | do                | do   | Do.           |
| 79                       | USGS 22981-PC                        | do                  | do                 | do                | do   | Do.           |
| 82                       | USGS 22983-PC                        | do                  | do                 | do                | do   | Ranchester.   |
| 83                       | USGS 22988-PC                        | do                  | do                 | do                | do   | Do.           |
| 84                       | USGS 22989-PC                        | do                  | do                 | do                | do   | Do.           |
| 85                       | USGS 22990-PC                        | do                  | do                 | do                | do   | Do.           |
| 86                       | USGS 6960-PC                         | do                  | do                 | do                | do   | Do.           |
| 87                       | USGS 22991-PC                        | do                  | do                 | do                | do   | Do.           |
| 89                       | USGS 22993-PC                        | Peak 9837           | do                 | do                | NE $\frac{1}{4}$ sec. 34, T. 34 N., R. 117 W.                  | Do.           |
| 92                       | USGS 6965-PC                         | Covey Cutoff        | do                 | do                | NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 27, T. 34 N., R. 117 W. | Moffat Trail. |
| 93                       | USGS 6951-PC                         | do                  | do                 | do                | do   | Do.           |
| 94                       | USGS 6965A-PC                        | do                  | do                 | do                | do   | Ranchester.   |
| 95                       | USGS 6951A-PC                        | do                  | do                 | do                | do   | Do.           |
| 96                       | USGS 17908-PC                        | do                  | do                 | do                | do   | Do.           |
| 97                       | USGS 7965B-PC                        | do                  | do                 | do                | do   | Do.           |
| 98                       | USGS 6951B-PC                        | do                  | do                 | do                | do   | Do.           |
| 99                       | USGS 6965C-PC                        | do                  | do                 | do                | do   | Do.           |
| 100                      | USGS 6965D-PC                        | do                  | do                 | do                | do   | Do.           |
| 101                      | USGS 6965E-PC                        | do                  | do                 | do                | do   | Do.           |
| 109                      | USGS 23002-PC                        | South Indian Creek. | Snake River Range. | do                | NE $\frac{1}{4}$ sec. 14, T. 38 N., R. 118 W.                  | Moffat Trail. |
| 117                      | USGS 18788-PC                        | Hoback Canyon       | Hoback range.      | Teton             | Sec. 2, T. 38 N., R. 115 W.                                    | Horseshoe.    |
| 118                      | USGS 16207-PC                        | do                  | do                 | do                | do   | Do.           |
| 120                      | USGS 18791-PC                        | do                  | do                 | do                | do   | Moffat Trail. |
| 121                      | USGS 16208-PC                        | do                  | do                 | do                | do   | Do.           |
| 122                      | USGS 16209-PC                        | do                  | do                 | do                | do   | Do.           |
| 129                      | USGS 23000-PC                        | do                  | do                 | do                | do   | Ranchester.   |
| 130                      | USGS 18786-PC                        | do                  | do                 | do                | do   | Do.           |
| 131                      | USGS 16210-PC                        | do                  | do                 | do                | do   | Do.           |
| 133                      | USGS 6189-PC                         | Tosi Ridge          | Gros Ventre Range  | Sublette          | Sec. 1, T. 38 N., R. 112 W.                                    | Do.           |
| 134                      | USGS 6192-PC                         | Hodges Peak         | do                 | do                | NW $\frac{1}{4}$ sec. 26, T. 39 N., R. 112 W.                  | Do.           |
| 136                      | USGS 6190-PC                         | Granite Creek       | do                 | Teton             | Sec. 4, T. 39 N., R. 113 W.                                    | Do.           |
| 137                      | USGS 6191-PC                         | Darwin Peak         | do                 | do                | S $\frac{1}{2}$ sec. 28, T. 40 N., R. 112 W.                   | Horseshoe.    |
| 138                      | USGS 6191B-PC                        | do                  | do                 | do                | do   | Do.           |
| 139                      | USGS 6191A-PC                        | do                  | do                 | do                | do   | Ranchester.   |
| 140                      | USGS 6191C-PC                        | do                  | do                 | do                | do   | Do.           |
| 141                      | USGS 6193-PC                         | Black Peak          | do                 | do                | Probably sec. 7, T. 40 N., R. 112 W.                           | Do.           |
| 142                      | USGS 6193A-PC                        | do                  | do                 | do                | Probably sec. 7 or 18, T. 40 N., R. 112 W.                     | Do.           |
| 143                      | USGS 6194-PC                         | Pyramid Peak        | do                 | do                | Probably SE $\frac{1}{4}$ sec. 6, T. 40 N., R. 113 W.          | Do.           |
| 145                      | USGS 23006-PC                        | Phillips Canyon     | Teton Range        | do                | SW $\frac{1}{4}$ sec. 16, T. 41 N., R. 117 W.                  | Moffat Trail. |
| 146                      | USGS 23004-PC                        | Glory Mountain      | do                 | do                | SE $\frac{1}{4}$ sec. 13, T. 41 N., R. 118 W.                  | Ranchester.   |
| 148                      | USGS 18776-PC                        | Darby Canyon        | do                 | do                | NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 15, T. 43 N., R. 118 W. | Do.           |
| 149                      | USGS 20229-PC                        | Berry Creek         | do                 | do                | NW $\frac{1}{4}$ sec. 22, T. 47 N., R. 116 W.                  | Horseshoe.    |
| 150                      | USGS 24055-PC                        | do                  | do                 | do                | do   | Do.           |
| 151                      | USGS 24051-PC                        | do                  | do                 | do                | do   | Do.           |
| 152                      | USGS 24058-PC                        | do                  | do                 | do                | do   | Do.           |
| 153                      | USGS 24059-PC                        | do                  | do                 | do                | do   | Do.           |



TABLE 3.—Checklist of brachiopod collections—Continued

| Collection No. in report | Permanent institutional locality No. | Name of locality | Mountain range    | County  | Location                          | Member      |
|--------------------------|--------------------------------------|------------------|-------------------|---------|-----------------------------------|-------------|
| 154 ----                 | USGS 24060-PC                        | Berry Creek      | Teton Range       | Teton   | NW¼ sec. 22, T., 47 N., R. 116 W. | Horseshoe.  |
| 155 ----                 | USGS 24052-PC                        | do               | do                | do      | do                                | Do.         |
| 156 ----                 | USGS 24056-PC                        | do               | do                | do      | do                                | Do.         |
| 157 ----                 | USGS 20230-PC                        | do               | do                | do      | do                                | Do.         |
| 158 ----                 | USGS 24053-PC                        | do               | do                | do      | do                                | Do.         |
| 159 ----                 | USGS 24050-PC                        | Elk Ridge        | do                | do      | do                                | Do.         |
| 160 ----                 | USGS 24057-PC                        | do               | do                | do      | do                                | Ranchester. |
| A -----                  | USNM Nos.                            | Enterprise ditch | Wind River Range. | Fremont |                                   | Horseshoe.  |
| B -----                  | do                                   | Amsden Hill      | do                | do      |                                   | Do.         |
| C -----                  | do                                   | Cherry Creek     | do                | do      |                                   | Do.         |
| D -----                  | do                                   | Youngs Basin     | do                | do      |                                   | Do.         |
| E -----                  | do                                   | Near Lander      | do                | do      |                                   | Do.         |
| F -----                  | do                                   | Fremont County   | do                | do      |                                   | Do.         |

ber, but it includes some beds in Lincoln County that probably are older than the lowest known in the Horseshoe. Characteristic of the Moffat Trail is its coral fauna which belongs to what is widely known as the *Caninia* Zone (K Zone of Dutro and Sando, 1963, p. 1974). Brachiopods are not very common in the coral beds, but *Composita*, particularly *C. subquadrata* (Hall), and *Anthracospirifer curvilateralis brutus* n. subsp. are present at several localities. Our 14 Moffat Trail brachiopod collections are from two counties in western Wyoming.

*Lincoln County.*—Collections (collns. 72, 73, 75–79, 92, 93, 109) made in the Bear Creek, Moffat Trail, Covey Cutoff, and South Indian Creek sections have yielded the following brachiopods. The meaning of symbols: R, rare; X, fairly common; C, common; A, abundant.

|  |   |
|--|---|
| <i>Pulsia</i> sp. A  | R |
| <i>Orthotetes?</i> sp  | R |
| <i>Diaphragmus cestriensis</i> (Worthen)                       | C |
| <i>Antiquatonia</i> sp   | R |
| <i>Ovatia muralis</i> n. sp                                    | X |
| Linopproductid gen. and sp. indet                              | R |
| <i>Coledium fragum</i> n. sp                                   | X |
| <i>Cleiothyridina</i> aff. <i>C. sublamellosa</i> (Hall)       | R |
| <i>Composita subquadrata</i> (Hall)                            | C |
| <i>Composita</i> sp. indet                                     | C |
| <i>Anthracospirifer curvilateralis curvilateralis</i> (Easton) | C |
| <i>Anthracospirifer curvilateralis brutus</i> n. subsp         | X |

*Teton County.*—Collections in the Hoback Canyon and Phillips Canyon sections (collns. 120–122, 145) include some of the same brachiopods:

|  |   |
|--|---|
| <i>Orthotetes kaskaskiensis bransonorum</i> n. subsp           | X |
| <i>Diaphragmus cestriensis</i> (Worthen)                       | C |
| <i>Ovatia muralis</i> n. sp                                    | R |
| <i>Composita subquadrata</i> (Hall)                            | X |
| <i>Composita</i> sp. indet                                     | X |
| <i>Anthracospirifer curvilateralis curvilateralis</i> (Easton) | C |
| <i>Neospirifer praenuntius</i> Easton                          | R |
| <i>Eumetria?</i> sp. indet                                     | R |

## HORSESHOE SHALE MEMBER

Fifty collections of brachiopods from the Horseshoe Shale Member in four Wyoming counties and one adjacent county in Montana were studied. Of these more than four-fifths are Late Mississippian (Chesterian) in age, including the 17 from Teton County and 23 from Fremont County Wyo., and one from Carbon County, Mont. Farther to the east and southeast, however, the two collections from Johnson County and seven from Carbon County, Wyo. are Early Pennsylvanian (Morrowan) in age.

*Teton County.*—Four separate faunules can be recognized in the Horseshoe Shale Member in Teton County, all of them Mississippian in age. The first and probably the oldest occurs beneath the Moffat Trail Limestone Member in the section at Hoback Canyon (collns. 117, 118).

*Composita* aff. *C. laevis* Weller C  
*Composita* sp. indet C  
*Anthracospirifer curvilateralis brutus* n. subsp C  
This assemblage, despite its occurrence in beds of Horseshoe Shale Member lithology, is the same as that normally found in the Moffat Trail Limestone Member.

The second assemblage is from Soda Creek in the Washakie Range (colln. 41) and contains the following brachiopods:

|  |   |
|--|---|
| <i>Schizophoria depressa</i> Easton                | R |
| Orthotetoid, gen. and sp. indet                    | R |
| <i>Inflatia lovei</i> n. sp                        | X |
| <i>Diaphragmus nivosus</i> n. sp                   | X |
| <i>Antiquatonia?</i> sp                            | R |
| <i>Cleiothyridina atrypoides saginata</i> n. subsp | R |
| <i>Composita</i> aff. <i>C. laevis</i> Weller      | R |
| <i>Composita subquadrata</i> (Hall)                | C |
| <i>Brachythyridina washakiensis</i> n. sp          | X |
| <i>Reticulariina?</i> sp. indet                    | R |

Like the other assemblage, this faunule occurs in beds regarded as equivalent temporally to part of

the Moffat Trail and its *Caninia* Zone fauna. The Soda Creek locality is unique in having *Diaphragmus nivosus* n. sp., *Cleiothyridina atrypoides saginata* n. subsp., and *Brachythyridina washakiensis* n. sp., which have not been found anywhere else in the Amsden formation. *D. nivosus* is a typical species in the Heath Shale of Montana where it is associated with *Composita subquadrata* (Hall), a species restricted to the *Caninia* Zone and its equivalents in the Amsden Formation.

The third faunule occurs in the Darwin Peak section and is the one for which Girty (in Blackwelder, 1918, p. 422) suggested a Mississippian age. The brachiopods at this locality (collns. 137, 138) are as follows:

|  |       |   |
|--|-------|---|
| <i>Cleiothyridina hirsuta darwinensis</i> n. subsp | ----- | X |
| <i>Composita sigma</i> n. sp                       | ----- | X |
| <i>Torynifer setiger</i> (Hall)?                   | ----- | R |
| <i>Anthracospirifer shawi shawi</i> n. subsp       | ----- | X |

This represents the lower fauna of the same member in the Wind River Range, Fremont County.

The fourth and highest faunule occurs in reddish-gray shale and interlayered gray limestone of the Horseshoe Shale Member at Berry Creek and Elk Ridge in the Teton Range (collns. 149-159), which have yielded the following brachiopods:

|   |       |   |
|---|-------|---|
| <i>Orthotetes kaskaskiensis bransonorum</i> n. subsp                  | ----- | C |
| <i>Eolissochonetes pseudoliratus</i> (Easton)                         | ----- | A |
| <i>Ovatia croneisi</i> (C. Branson)?                                  | ----- | R |
| <i>Composita sigma</i> n. sp  | ----- | X |
| <i>Anthracospirifer shawi exoletus</i> n. subsp                       | ----- | R |
| <i>Anthracospirifer welleri lincolnensis</i> n. subsp                 | ----- | A |
| <i>Anthracospirifer</i> aff. <i>A. occidentalis</i> (Sadlick), form A | ----- | A |

The anthracospirifers are facies controlled at this locality: *A. shawi exoletus* and *A. welleri lincolnensis* are restricted to the limestone layers, and *A. aff. A. occidentalis*, form A is found only in the shale. Associated foraminifers indicate latest Mississippian age for this assemblage.

*Fremont County.*—Most of the earlier work on the fossils of the Amsden Formation has been based on localities in the Wind River Range, and all of them seem to have come from the Horseshoe Shale Member. In this area two assemblages have been recognized (Shaw and Bell, 1955; Shaw, 1955), a lower assemblage (*Spirifer welleri* fauna of Shaw, 1955) and an upper assemblage (*Spirifer "opimus"* fauna of Shaw, 1955). By some fortunate circumstance the fossils of the upper zone are silicified, and many of them have been replaced by chert, whereas those of the lower fauna are calcareous. This condition is demonstrated by Bell's specimens (in the collections of the University of Wyoming) which he obtained in place by trenching the section at

Cherry Creek. The faunal differences noted in comparing loose silicified fossils with calcareous ones are largely borne out by the roster of fossils collected in situ at the lower and higher levels.

The lower fauna (*Carlinia amsdeniana* assemblage), (collns. 21, 22, 26b-31, 36a [part], 36b [part], 43 [part], 44-48) at South Pass, Cherry Creek, Amsden Hill, Horse Creek, Wiggins Fork, and Livingston Ranch is as follows:

|  |       |   |
|--|-------|---|
| <i>Lingula</i> cf. <i>L. carbonaria</i> Shumard              | ----- | R |
| <i>Orbiculoidea wyomingensis</i> Branson and Greger          | ----- | R |
| <i>Orbiculoidea</i> sp. A                                    | ----- | R |
| <i>Schizophoria depressa</i> Easton                          | ----- | R |
| <i>Schizophoria</i> aff. <i>S. texana</i> Girty              | ----- | R |
| <i>Orthotetes kaskaskiensis bransonorum</i> n. subsp         | ----- | R |
| <i>Orthotetina amsdenensis</i> (Branson and Greger)          | ----- | R |
| <i>Ovatia croneisi</i> (C. Branson)                          | ----- | X |
| <i>Inflatia lovei</i> n. sp                                  | ----- | C |
| <i>Carlinia amsdeniana</i> Gordon                            | ----- | C |
| <i>Flexaria</i> sp   | ----- | R |
| <i>Ovatia croneisi</i> (C. Branson)                          | ----- | X |
| <i>Ovatia muralis</i> n. sp                                  | ----- | R |
| <i>Cleiothyridina hirsuta darwinensis</i> n. subsp           | ----- | X |
| <i>Cleiothyridina</i> aff. <i>C. elegans</i> Girty           | ----- | R |
| <i>Composita sigma</i> n. sp                                 | ----- | C |
| <i>Composita poposiensis</i> n. sp. (early form)             | ----- | R |
| <i>Torynifer setiger</i> (Hall)?                             | ----- | R |
| <i>Anthracospirifer welleri welleri</i> (Branson and Greger) | ----- | C |
| <i>Anthracospirifer shawi shawi</i> n. subsp                 | ----- | X |
| <i>Reticularina browni</i> (Branson and Greger)              | ----- | X |
| <i>Eumetria sulcata</i> Burk                                 | ----- | X |
| <i>Gitryella</i> cf. <i>G. indianensis</i> (Girty)           | ----- | R |

These include the fossils collected in place by Bell (in Shaw and Bell, 1955, fig. 1) 45 to 48 feet above the base of the Amsden at Cherry Creek, and fossils collected by Love (1939, p. 28) at Wiggins Fork.

The higher fauna (*Composita poposiensis* assemblage), (collns. 19, 26a, 32, 34, 36a [part], 38, 42, 43 [part]) is as follows:

|   |       |   |
|---|-------|---|
| <i>Orbiculoidea wyomingensis</i> (Branson and Greger)                 | ----- | R |
| <i>Orthotetoid</i> , gen. and sp. indet                               | ----- | R |
| <i>Ovatia croneisi</i> (C. Branson)?                                  | ----- | R |
| <i>Ovatia muralis</i> n. sp?  | ----- | R |
| <i>Productoid</i> , gen. and sp. indet                                | ----- | R |
| <i>Pugnoides quinqueplecis</i> Easton                                 | ----- | X |
| <i>Composita poposiensis</i> n. sp                                    | ----- | A |
| <i>Composita sulcata</i> Weller                                       | ----- | X |
| <i>Composita</i> sp. indet  | ----- | X |
| <i>Anthracospirifer shawi exoletus</i> n. subsp                       | ----- | C |
| <i>Anthracospirifer</i> aff. <i>A. occidentalis</i> (Sadlick), form A | ----- | R |
| <i>Eumetria sulcata</i> Burk  | ----- | X |

Included in this list are the fossils collected by Bell (Shaw and Bell, 1955, fig. 1) in place 65 to 68 feet above the base of the Amsden at Cherry Creek. These highest fossiliferous beds of the Horseshoe Shale Member in Fremont County are regarded as approximating in age the beds on Berry Creek,

Teton County, that bear the same and similar anthracospirifers. The compositas, however, are different at the two localities, as *C. poposiensis* n. sp. is restricted to Fremont County.

**Carbon County, Mont.**—On top of the bluffs of the Bighorn River opposite the mouth of Devil's Canyon, roughly one-quarter of a mile north of the Wyoming-Montana State line, a small collection of silicified brachiopods from a limestone layer about 15 feet above the top of the Madison Limestone (colln. 69) yielded the following brachiopods:

|   |   |
|---|---|
| <i>Schuchertella</i> cf. <i>S. poposiensis</i> (C. Branson) ..... | R |
| <i>Pugnoides quinqueplecis</i> Easton .....                       | C |
| <i>Cleiothyridina</i> sp. indet .....                             | R |
| <i>Reticularina browni</i> (Branson and Greger) .....             | X |
| <i>Eumetria sulcata</i> Burk .....                                | R |

The presence of *Pugnoides quinqueplecis* and *Eumetria sulcata* in association in this faunule indicates an equivalence to the *Composita poposiensis* fauna in the Wind River Range.

**Johnson County.**—In the Lake de Smet area, on the South Fork of Rock Creek, two collections (collns. 53, 54) from the Horseshoe Shale Member have provided fossils of Early Pennsylvanian age. The brachiopods are as follows:

|   |   |
|---|---|
| <i>Orthotetes</i> sp. A .....                         | X |
| <i>Juresania</i> sp .....                             | R |
| <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> ..... | R |
| <i>Linoproductus eastoni</i> n. sp .....              | C |

These fossils came from the basal 2 feet of the member and thus indicate Pennsylvanian age for the entire Horseshoe Shale Member in that area.

**Carbon County.**—The Amsden Formation in the region of the Rawlins hills contains the youngest faunas found in this study. The Horseshoe Shale Member in that area contains brachiopods and mollusks of Morrowan age associated with the coral *Neokoninckophyllum hamatilis* Sando and *N. inconstans* Sando. Brachiopods from seven collections in the Cherokee Spring, Cherokee Peak, and Meadow Ranch sections (collns. 1-5, 7, 8) are as follows:

|   |   |
|---|---|
| <i>Orbiculoidea</i> sp. B .....                               | R |
| <i>Derbyia</i> cf. <i>D. robusta</i> (Hall) .....             | X |
| <i>Orthotetoid</i> , gen. and sp. indet .....                 | R |
| <i>Echinoconchus</i> sp. A .....                              | R |
| <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> (Girty) ..... | C |
| <i>Linoproductus eastoni</i> n. sp .....                      | R |
| <i>Linoproductus planiventralis</i> Hoare .....               | X |
| <i>Cleiothyridina</i> sp .....                                | R |
| <i>Composita ovata</i> Mather .....                           | C |
| <i>Composita elongata</i> Dunbar and Condra) .....            | X |
| <i>Anthracospirifer occidentalis</i> (Sadlick) .....          | C |
| <i>Anthracospirifer rawlinsensis</i> n. sp .....              | X |

#### RANCHESTER LIMESTONE MEMBER

Thirty-six collections containing brachiopods from the Ranchester Limestone Member have been

studied. These are distributed in six counties. The brachiopods range in age from very late Chesterian (Late Mississippian) to Atokan (Middle Pennsylvanian), the Mississippian ones being restricted to western Wyoming.

**Lincoln County.**—The oldest beds of the Ranchester Limestone Member were recorded in the Moffat Trail and Covey Cutoff sections (collns. 82, 95-98) and contained these brachiopods.

|  |   |
|--|---|
| <i>Pulsia</i> sp. A .....                                    | R |
| <i>Eolissochonetes pseudoliratus</i> (Easton) ? .....        | R |
| <i>Inflatia lovei</i> n. sp? .....                           | X |
| <i>Pugnoides quinqueplecis</i> Easton .....                  | R |
| <i>Composita sigma</i> n. sp .....                           | C |
| <i>Anthracospirifer shawi exoletus</i> n. subsp .....        | R |
| <i>Anthracospirifer welleri lincolniensis</i> n. subsp ..... | C |

This assemblage, of undoubted Mississippian age, appears to correlate with the upper fauna of the Horseshoe Shale Member in Fremont County, despite the fact that the foraminiferal determinations indicate a slightly earlier age (Zone 18) than the beds on Berry Creek.

Higher beds in the same two sections and at Peak 9837 (collns. 83-87, 89, 99-101) carry a fauna of Early Pennsylvanian (Morrowan) age.

|  |   |
|--|---|
| <i>Schizophoria depressa</i> Easton .....            | X |
| <i>Rhipidomella carbonaria</i> (Shumard) .....       | C |
| <i>Orthotetes</i> sp. A? .....                       | X |
| <i>Orthotetoid</i> , gen. and sp. indet .....        | R |
| <i>Rugoclostus williamsi</i> n. sp .....             | X |
| <i>Juresania</i> sp .....                            | R |
| <i>Antiquatonia blackwelderi</i> n. sp .....         | X |
| <i>Linoproductus eastoni</i> n. sp? .....            | R |
| <i>Composita ovata</i> Mather? .....                 | R |
| <i>Composita</i> sp. indet .....                     | X |
| <i>Anthracospirifer occidentalis</i> (Sadlick) ..... | X |

Characteristic of this fauna are the productoids *Rugoclostus williamsi*, *Juresania* sp., *Antiquatonia blackwelderi*, and the spiriferid *Anthracospirifer occidentalis*.

**Sublette County.**—Only two collections are available from this county, and both of them are of Pennsylvanian age; it is not known whether or not the basal part of the member includes beds of Mississippian age. The collections from Tosi Ridge and Hodges Peak (collns. 133, 134) represent the *Antiquatonia blackwelderi* assemblage.

|  |   |
|--|---|
| <i>Orbiculoidea</i> sp. B? .....                     | R |
| <i>Eolissochonetes pseudoliratus</i> (Easton) .....  | A |
| <i>Juresania</i> sp .....                            | R |
| <i>Antiquatonia blackwelderi</i> n. sp .....         | X |
| <i>Linoproductus eastoni</i> n. sp .....             | X |
| <i>Anthracospirifer occidentalis</i> (Sadlick) ..... | R |

**Teton County.**—Two collections from the lower part of the member on the west slope of the Teton Range, at Glory Mountain and Darby Canyon (collns. 146, 148), contain an *Anthracospirifer*

closely related to the one in the Horseshoe Shale Member at Berry Creek, and the associated fauna indicates a Mississippian age. The brachiopods at these localities are as follows:

|   |   |
|---|---|
| <i>Orbiculoidea wyomingensis</i> (Branson and Greger)?                | R |
| <i>Orthotetoid</i> , gen. an dsp. indet                               | X |
| <i>Composita sigma</i> n. sp  | X |
| <i>Anthracospirifer</i> aff. <i>A. occidentalis</i> (Sadlick), form B | C |
| <i>Eumetria sulcata</i> Burk  | X |

At Elk Ridge on the north end of the Teton Range, the lower limestone unit of the Ranchester Limestone Member (colln. 160) contains two brachiopod species of Mississippian age—*Composita sigma* n. sp. and *Anthracospirifer shawi exoletus* n. subsp.

Most of the Ranchester in Teton County is Pennsylvanian in age. The *Antiquatonia blackwelderi* assemblage appears for the first time fairly low in the member; fossil collections from localities at Hoback Canyon, Granite Creek, Darwin Peak, Black Peak, and Pyramid Peak (collns. 130, 131, 136, 139–143) contain the following brachiopods:

|   |   |
|---|---|
| <i>Lingula</i> cf. <i>L. carbonaria</i> Shumard | R |
| <i>Schizophoria</i> aff. <i>S. texana</i> Girty | R |
| <i>Orthotetoid</i> , gen. and sp. indet         | X |
| <i>Eolissochonetes pseudoliratus</i> (Easton)   | C |
| <i>Juresania</i> sp                             | R |
| <i>Antiquatonia blackwelderi</i> n. sp          | X |
| <i>Linoproductus eastoni</i> n. sp              | X |
| <i>Cleiothyridina</i> sp                        | R |
| <i>Composita ovata</i> Mather                   | X |
| <i>Composita elongata</i> Dunbar and Condra     | R |
| <i>Composita subtilita</i> (Hall)               | X |
| <i>Anthracospirifer occidentalis</i> (Sadlick)  | R |

**Sheridan County.**—In the type region of the Amsden Formation, all the fossils studied are of Morrowan age and have come from the Ranchester Limestone Member, where they occur silicified in impure limestone beds. The fauna from three localities on Amsden Creek (collns. 63, 67, 68) is as follows:

|   |   |
|---|---|
| <i>Schizophoria depressa</i> Easton                     | R |
| <i>Schizophoria</i> aff. <i>S. texana</i> Girty         | C |
| <i>Eolissochonetes pseudoliratus</i> (Easton)           | R |
| <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> (Girty) | R |
| <i>Composita ovata</i> Mather?                          | R |
| <i>Composita</i> sp. indet                              | R |

**Johnson County.**—The only Ranchester fossils from this county came from a calcareous sandstone bed near the top of the member (colln. 52), on North Fork, Crazy Woman Creek. This brachiopod-mollusk faunule is the one upon which Darton (1906, p. 33, 34) first based the Pennsylvanian age of the upper part of the Amsden Formation. The brachiopods, as reidentified in the present report, are as follows:

|                                    |   |
|------------------------------------|---|
| <i>Pulsia delira</i> n. sp         | R |
| <i>Juresania</i> sp                | R |
| <i>Anthracospirifer?</i> sp. indet | R |

Whether the beds at this locality are late Morrowan or early Atokan in age is not presently known.

**Carbon County.**—Four collections from the Ranchester Limestone Member in this county include rocks of both Morrowan and Atokan age. Those of Morrowan age are from the Meadow Ranch and Buck Spring sections (collns. 13, 14) and include the following brachiopods:

|   |   |
|---|---|
| <i>Schizophoria</i> aff. <i>S. texana</i> Girty         | X |
| <i>Scolocoencha globosa</i> (Mather)                    | R |
| <i>Echinoconchus</i> sp. A                              | R |
| <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> (Girty) | X |
| <i>Composita ovata</i> Mather                           | A |
| <i>Anthracospirifer occidentalis</i> (Sadlick), var     | R |

The Morrowan age of this faunule is confirmed by Foraminifera found in the same beds.

A faunule of Atokan age was recorded on U.S. Highway 287 near Rawlins and at Belle Springs (collns. 6, 15). Most of the species occur also in the beds of Morrowan age.

|   |   |
|---|---|
| <i>Derbyia</i> cf. <i>D. robusta</i> (Hall)?            | R |
| <i>Mesolobus</i> sp                                     | R |
| <i>Echinoconchus</i> sp. A                              | R |
| <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> (Girty) | C |
| <i>Linoproductus planiventralis</i> Hoare               | X |
| <i>Composita subtilita</i> (Hall)                       | C |
| <i>Anthracospirifer occidentalis</i> (Sadlick)          | X |

This faunule is regarded as Atokan in age because, despite the similarity of most of the brachiopods to those of known Morrowan age in the eastern areas of Amsden outcrop, the faunule contains *Mesolobus*, a genus that is restricted to rocks of Atokan and Des Moinesian age. Foraminifera in the same beds confirm their Atokan age.

#### ZONAL DISTRIBUTION OF THE BRACHIOPODS

In table 4 the stratigraphic distribution of 57 Amsden brachiopods is equated with the occurrence of foraminiferal zones and coral assemblages. Also shown, by numbers following each species, is their presence in three geographic regions: western, west-central, and east-central Wyoming, the last including the Rawlins hills. Western Wyoming includes Lincoln, Sublette, and Teton Counties; west-central Wyoming is restricted to Fremont County, and east-central Wyoming includes Sheridan, Johnson, Washakie, and Carbon Counties. A glance at this chart will show that the brachiopods have considerable use biostratigraphically.

For the purpose of biostratigraphic correlation, as discussed by Sando, Gordon, and Dutro (1975), several faunal zones have been recognized. Some of these zones, at least in the Mississippian rocks,

have different boundaries from the foraminiferal zones of Mamet and so, in combination, permit a relatively detailed breakdown of the stratigraphic section. Table 5 lists the megafaunal zones which are recognized within the Amsden Formation of Wyoming.

Although no single section contains all the zones,

their superposition in this order seems assured. Pennsylvanian zones have not been differentiated in northeast-central Wyoming (Sheridan, Johnston, and Washakie Counties), but several localities there contain Zone 20 Foraminifera, indicating Morrowan age. The subject of faunal zones is discussed more fully by Sando Gordon, and Dutro (1975).

TABLE 4.—Stratigraphic distribution of Amsden brachiopods equated with foraminifer zones and coral occurrences

| Age           | Foraminifer zones | Coral occurrences | Orthotetoid brachiopods  | Productoid brachiopods  | Composita  | Anthracospirifer   | Other brachiopods   |   |
|---------------|-------------------|-------------------|--|---|--|--|---|---|
| Pennsylvanian | Atokan            | 21                |  | <i>Derbyia</i> cf. <i>D. robusta</i> <sup>1</sup>   | <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> <sup>1</sup><br><i>Linoproductus planiventralis</i>  | <i>C. ovata</i> <sup>1</sup><br><i>C. subtilita</i> <sup>1</sup>   | <i>A. occidentus</i> <sup>1</sup><br><br><i>Mesolobus</i> sp. <sup>1</sup>  |   |
|               | Morrowan          | 20                | <i>Neokoninckophyllum hamatilis</i> <sup>1</sup><br><br><i>Pulsia delira</i> <sup>2</sup><br><br><i>Derbyia</i> cf. <i>D. robusta</i> <sup>1</sup><br><br><i>Orthotetes</i> sp. A <sup>1 3</sup>   | <i>Antiquatonia</i> cf. <i>A. coloradoensis</i> <sup>1</sup><br><i>Linoproductus planiventralis</i> <sup>1</sup><br><i>Scolocoencha globosa</i> <sup>2</sup><br><i>Echinoconchus</i> sp. A <sup>1</sup><br><i>Juresania</i> sp. <sup>2 3</sup><br><i>Antiquatonia blackwelderi</i> <sup>3</sup><br><i>Linoproductus eastoni</i> <sup>1 3</sup><br><i>Rugoclostus williamsi</i> <sup>3</sup> | <br><br><br><i>C. ovata</i> <sup>2</sup><br><br><i>C. elongata</i> <sup>1 3</sup><br><br><i>C. subtilita</i> <sup>3</sup>  | <br><br><br><i>A. rawlinsensis</i> <sup>1</sup><br><br><i>A. occidentus</i> <sup>1 3</sup>               | <br><br><br><i>Rhipidomella carbonaria</i> <sup>3</sup><br><i>Orbiculoidea</i> sp. B <sup>1</sup><br><i>Schizophoria</i> aff. <i>S. texana</i> <sup>1 3</sup><br><i>Schizophoria depressa</i> <sup>2 3</sup><br><i>Eolissochonetes pseudoliratus</i> <sup>2</sup>   |   |
| Mississippian | Chesterian        | 19                | <i>Barytichisma amsdenensis</i> <sup>2</sup>   | <i>Orthotetes kaskaskiensis bransonorum</i> <sup>2 3</sup>  | <i>Ovatia croneisi</i> ? <sup>3</sup>  | <i>C. sigma</i> <sup>3</sup><br><br><i>C. sulcata</i> <sup>2</sup><br><i>C. poposiensis</i> <sup>2</sup> | <i>A. aff. A. occidentus</i> <sup>2 3</sup><br><i>A. shawi exoletus</i> <sup>2 3</sup><br><i>A. welleri lincolnensis</i> <sup>3</sup>   | <i>Eolissochonetes pseudoliratus</i> <sup>3</sup><br><i>Pugnoides quinqueplexis</i> <sup>2 3</sup><br><i>Orbiculoidea wyomingensis</i> <sup>2</sup><br><i>Eumetria sulcata</i> <sup>2 3</sup> |
|               |                   |                   | <i>Orthotetina amsdenensis</i> <sup>2</sup><br><br><i>Orthotetes kaskaskiensis bransonorum</i> <sup>2</sup><br><br><i>Schuchertella poposiensis</i> <sup>2</sup>   | <i>Ovatia croneisi</i> <sup>2</sup><br><br><i>Ovatia muralis</i> <sup>2 3</sup><br><br><i>Carlinia amsdeniana</i> <sup>2</sup><br><i>Inflatia lovei</i> <sup>2</sup><br><i>Flexaria</i> sp. <sup>2</sup>  | <i>C. poposiensis</i> <sup>2</sup> (early form)<br><br><br><i>C. sigma</i> <sup>2 3</sup>  | <i>A. shawi shawi</i> <sup>2 3</sup><br><br><i>A. welleri welleri</i> <sup>2</sup>                       | <i>Orbiculoidea wyomingensis</i> <sup>2</sup><br><i>Orbiculoidea</i> sp. A <sup>2</sup><br><i>Schizophoria depressa</i> <sup>2</sup><br><i>Schizophoria</i> aff. <i>S. texana</i> <sup>2</sup><br><i>Cleiothyridina hirsuta darwinensis</i> <sup>2</sup><br><i>Reticularina browni</i> <sup>2</sup><br><i>Eumetria sulcata</i> <sup>2</sup> |   |
|               |                   | 18                | <i>Chaetetes wyomingensis</i> <sup>3</sup><br><i>Multithecopora? amsdenensis</i> <sup>3</sup><br><i>Duncanopora duncanae</i> <sup>3</sup><br><i>Pleurosiphonella drummondii</i> <sup>3</sup><br><i>Caninia</i> cf. <i>C. nevadensis</i> <sup>3</sup><br><i>Lonsdaleia (Actinocyathus) stelcki</i> <sup>3</sup> | <i>Pulsia</i> sp. A <sup>3</sup>  | <i>Diaphragmus nivosus</i> <sup>3</sup><br><i>Inflatia lovei</i> <sup>3</sup><br><br><i>Antiquatonia</i> sp. <sup>3</sup><br><br><i>Diaphragmus cestriniensis</i> <sup>3</sup> | <br><br><br><br><br><i>C. subquadrata</i> <sup>3</sup><br><br><i>C. aff. C. laevis</i> <sup>3</sup>      | <i>Brachythyridina washakienensis</i> <sup>3</sup><br><br><br><br><br><i>Neospirifer praenuntius</i> <sup>2</sup><br><i>A. curvilateralis</i> <sup>3</sup><br><i>A. c. brutus</i> <sup>3</sup>  | <i>Schizophoria depressa</i> <sup>3</sup><br><i>Cleiothyridina atrypoides saginata</i> <sup>3</sup><br><br><br><br><br><i>Coledium fragum</i> <sup>3</sup>                                    |
|               |                   | 17                |  |   | <i>Orthotetes</i> sp. <sup>3</sup>   | <i>Ovatia muralis</i> <sup>3</sup>   |   |   |

<sup>1</sup> Occurs in east-central Wyoming.

<sup>2</sup> Occurs in west-central Wyoming.

<sup>3</sup> Occurs in western Wyoming.

TABLE 5.—Coral and brachiopod zones of the Amsden Formation of Wyoming

| Age           | Zone  |
|---------------|---|
| Pennsylvanian | Atokan<br><i>Mesolobus</i> Zone <sup>1</sup>  |
|               | Morrowan<br><i>Neokoninckophyllum hamatilis</i> Zone <sup>1</sup><br><i>Antiquatonia blackwelderi</i> Zone <sup>3</sup>   |
| Mississippian | Chesterian<br><i>Anthracospirifer welleri-shawi</i> Zone <sup>2,3</sup><br><i>Composita poposiensis</i> Subzone <sup>2</sup><br><i>Carlinia amsdeniana</i> Subzone <sup>2</sup><br><i>Caninia</i> Zone <sup>3</sup> |

<sup>1</sup> Southeast-central Wyoming.

<sup>2</sup> Central Wyoming.

<sup>3</sup> Western Wyoming—Teton, Lincoln, and Sublette Counties.

## ANALYSIS OF FAUNAL RELATIONSHIPS

The brachiopod study has turned up facts as to taxonomic similarities and differences, geographic distribution, stratigraphic succession, relative abundance, and various habitats of the fauna. Let us now briefly review the fauna by major groups, discuss the implications of these facts, and interpret some of the faunal relationships and their bearing upon the depositional history of the Wyoming basin.

Table 4 indicates that most of the brachiopods have rather limited stratigraphic ranges. Most of them occur rather sporadically and with a few exceptions do not reveal any evolutionary trends. The few exceptions are the *Orthotetes-Derbyia* succession and the very abundant genera *Composita* and *Anthracospirifer*, which account, in numbers of individuals, for more than two-thirds of our collections.

## INARTICULATES

As one would suspect, the long-ranging and fairly stable genera *Lingula* and *Orbiculoidea* provide relatively little of stratigraphic value. The species identified as *Lingula* cf. *L. carbonaria* Shumard is found in both the Mississippian and the Pennsylvanian parts of the formation. However, *Orbiculoidea wyomingensis* Branson and Greger and the very eccentric *O. sp. A* are restricted to the *Anthracospirifer welleri-shawi* Zone, whereas a third species *O. sp. B* occurs in the *Neokoninckophyllum hamatilis* Zone.

## ORTHIDS

Two species of *Schizophoria*, *S. depressa* Easton and *S. aff. S. texana* Girty, have fairly long ranges and are found on both sides of the Mississippian-Pennsylvanian boundary. The ubiquitous Pennsylvanian species *Rhipidomella carbonaria* (Swallow) was found in a single bed in the Morrowan part of the section.

## ORTHOTETIDS

Eight species belonging in five genera occur in the Amsden. The Meekellidae are represented by *Pulsia* sp. A in the *Caninia* Zone and overlying *Anthracospirifer welleri-shawi* Zone in western Wyoming, by *Orthotetina amsdenensis* (Branson and Greger) in the *Carlinia amsdeniana* Subzone in west-central Wyoming, and by *Pulsia delira* n. sp. in Pennsylvanian rocks near the top of the formation in east-central Wyoming.

*Schuchertella poposiensis* (C. Branson) occurs in west-central Wyoming, presumably in the *Carlinia amsdeniana* Subzone.

The Orthotetidae are represented by the somewhat aberrant shell having a fairly high interarea, described as *Orthotetes* sp., in the *Caninia* Zone and the low interarea form *O. kaskaskiensis bransonorum* n. subsp. in the *Anthracospirifer welleri-shawi* Zone. An evolutionary trend that involves the diminution in size of the spondylium in the pedicle valve and a change to multicostellate sculpture gives rise to *O. sp. A* in the Early Pennsylvanian *Antiquatonia blackwelderi* Zone. This species is probably the same *Orthotetes* that occurs in the Cameron Creek Member of the Tyler Formation and Alaska Bench Limestone in south-central Montana. The latest species of this family in the Amsden is *Derbyia* cf. *D. robusta* (Hall), which is very close to the typical midcontinent form.

## CHONETIDS

Besides *Eolissochonetes? suttoni* (C. Branson), which cannot be recognized because its internal characters are not known, the only chonetid in the

Mississippian part of the formation is *E. pseudoliratus* (Easton), which appears in western Wyoming near the top of the *Anthracospirifer welleri-shawi* Zone and continues across the Mississippian-Pennsylvanian boundary into the *Antiquatonia blackwelderi* Zone. In the Rawlins hills, an early form of *Mesolobus* characterizes a faunule of early Atokan age.

## PRODUCTOIDS

Sixteen species of productoid brachiopods belonging in 11 genera have been recognized in the Amsden. The genera *Inflatia*, *Flexaria*, *Diaphragmus*, *Carlinia*, and *Ovatia* are restricted to the Mississippian part of the formation. *Scoloconcha*, *Rugoclostus*, *Juresania*, *Echinoconchus*, and *Linoproductus* have been found only in the Pennsylvanian part. Elsewhere, however, *Scoloconcha* and *Echinoconchus* occur in rocks of Mississippian age. *Antiquatonia* has been recognized in both parts of the formation.

Among the Marginiferidae, *Inflatia lovei* n. sp., which occurs in the older part of the Horseshoe Shale Member and in the *Anthracospirifer welleri-shawi* Zone, is replaced by the *Inflatia*-like *Rugoclostus williamsi* n. sp. in the Pennsylvanian *Antiquatonia blackwelderi* Zone.

Among the Productidae, *Diaphragmus cestriensis* (Worthen), which occurs in the *Caninia* Zone, is a characteristic midcontinent species. *D. nivosus* n. sp. is known elsewhere only in the Heath Formation of south-central Montana. *Carlinia amsdeniana* Gordon, which characterizes the subzone of the same name, seems to be an endemic species.

*Antiquatonia blackwelderi* n. sp. occurs also in the Wells Formation of Idaho. In the eastern part of the Amsden outcrop it is replaced in beds of Morrowan age by *A. cf. A. coloradoensis* (Girty). No brachiopod collections are available from beds of Pennsylvanian age in the intervening central part of Wyoming.

## RHYCHONELLOIDS

Two rhynchonelloids in the Amsden Formation are the stenoscismatid *Coledium fragum* n. sp., from the *Caninia* Zone, and *Puginoides quinqueplecis* Easton, which is restricted to the *Compositia poposiensis* Subzone of very Late Mississippian age. *P. quinqueplecis* was described originally from south-central Montana and occurs there mainly in rocks of Pennsylvanian age.

## ATHYRIDS

The genus *Cleiothyridina* includes five different forms, none of which seems identical to previously



described forms. New subspecies have been erected for two of them. *C. atrypoides saginata* n. subsp. occurs in the older part of the Horseshoe Shale Member. *C. hirsuta darwinensis* n. subsp. is found fairly commonly in the *Carlinia amsdeniana* Subzone. A few specimens from the *Caninia* Zone were identified as *C. aff. C. sublamellosa* (Hall) and two from the *Carlinia amsdeniana* Subzone, as *C. aff. C. elegans* Girty. The few crushed Pennsylvanian specimens were not identifiable.

The genus *Composita* is represented by eight species (fig. 1), two of them new though previously described under other names. The earliest one, the ubiquitous Chesterian species *C. subquadrata* (Hall), occurs in the *Caninia* Zone. Locally in the Horseshoe Shale Member, adjacent to the limestones of the *Caninia* Zone, is a small narrow form described as *C. aff. C. laevis* Weller. This species probably was ancestral to *C. sigma* n. sp., the most widely distributed *Composita* in the *Anthracospirifer welleri-shawi* Zone. *C. sigma* is the only *Composita* in the *Carlinia amsdeniana* Subzone in central Wyoming; in the overlying subzone it is superseded by its descendant *C. poposiensis* and by *C. sulcata* Weller, a characteristic midcontinent species. These last two species do not occur, however, in western Wyoming, where *C. sigma* continues to the top of the Mississippian. Little doubt exists that *C. poposiensis* was an offshoot of *C. sigma*, differing from it mainly in having three fairly deep sulci in the pedicle valve in the typical form. The *C. sigma*-*C. poposiensis* complex seems to be endemic to the Wyoming depositional basin.

In the Morrowan part of the formation the *compositas* change abruptly, the typical species being *C. ovata* Mather, *C. elongata* Dunbar and Condra, and *C. subtilita* (Hall). They tend to be larger than the Mississippian forms. As these are widely distributed species in Pennsylvanian rocks of the United States, it is likely that they entered the Wyoming basin from the outside. Nevertheless, some similarities between *C. sigma* and *C. ovata* and a *C. subtilita*-like variant of *C. poposiensis* with *C. subtilita* raises the question whether the Pennsylvanian species may have been derived locally.

#### SPIRIFERIDS

The Spiriferidae are represented by seven species belonging in three genera. The most common are the five anthracospirifers, among which three of the species have been divided into two subspecies (fig. 2). They constitute a taxonomic succession of considerable biostratigraphic utility. The earliest

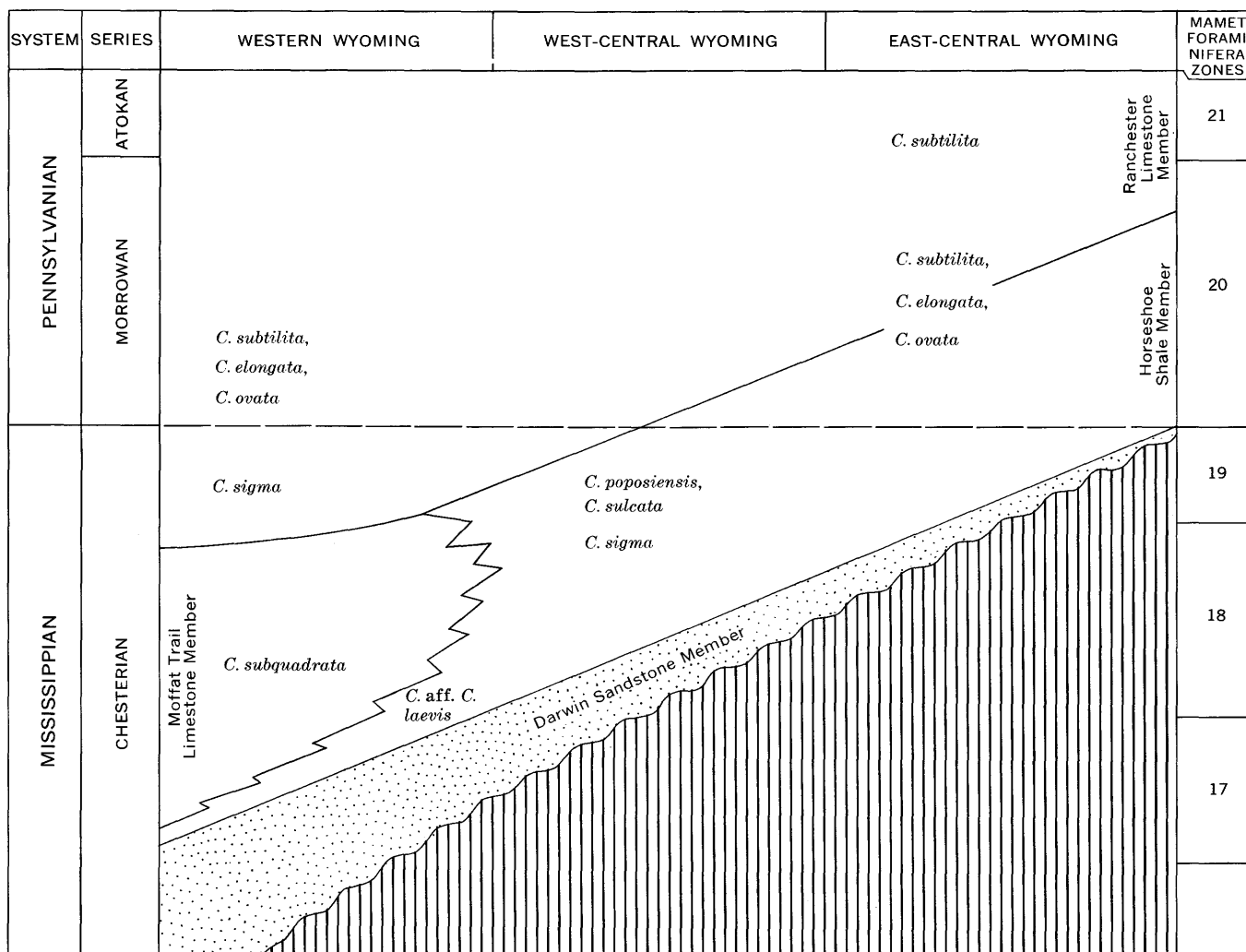
ones, *Anthracospirifer curvilateralis curvilateralis* Easton and *A. c. brutus* n. subsp. occur in the *Caninia* Zone. It seems likely that *A. c. curvilateralis* was ancestral to *A. welleri welleri* and *A. c. brutus* to *A. shawi shawi* of the *Carlinia amsdeniana* Subzone. The early forms of the central Wyoming species have about the same number of ribs, respectively, as their *Caninia* Zone progenitors, but the shell shapes are different and the sizes smaller.

Once established as distinct species in the same environment, the central Montana anthracospirifers began further differentiation. In the *Composita poposiensis* Subzone, *A. welleri* is missing entirely, and *A. shawi* is represented by the more complex and slightly larger subspecies *A. s. exoletus* n. subsp. The descendants of *A. welleri* occur only in western Wyoming, where the subspecies *A. w. lincolnensis* is recognized. Some small specimens within local populations there are fairly close to typical *A. welleri welleri* but are considered to belong within the range of variation of the western subspecies.

In uppermost Mississippian rocks exposed at Berry Creek in the Teton Range, an interesting assemblage shows a lithofacial differentiation of the anthracospirifers. *A. welleri lincolnensis* is abundant in limestone layers and is associated with rare *A. shawi exoletus*. Intervening layers of reddish-gray shale are crowded with what appears to be an early form of *A. occiduus*, here described as *A. aff. A. occiduus*, form A. The early (pre-Pennsylvanian) occurrence of an *occiduus*-like shell indicates that this area may have been the cradle of that ubiquitous Pennsylvanian species. It is not clear, however, whether this form was introduced from outside the Wyoming depositional basin or whether it began here as a modification of *A. shawi exoletus*. A single specimen of *A. aff. A. occiduus* form A has been recognized in the *Composita poposiensis* Subzone in the Wind River Mountains.

Typical *A. occiduus* is the dominant anthracospirifer in the Pennsylvanian part of the Amsden, occurring in rocks of both Morrowan and Atokan age. Another Pennsylvanian species, *A. rawlinsensis* n. sp., is found sparingly in beds of late Morrowan age in southeast-central Wyoming. This species has the greatest number of costae of all the Amsden anthracospirifers. Similar and perhaps conspecific shells are known in the east-central part of the Great Basin.

Other spiriferids include a shell fragment from the fringes of the *Caninia* Zone identified as *Neospirifer praenuntius* Easton and *Brachythyryna washakiensis* n. sp. from the older part of the Horse-

FIGURE 1.—Distribution of *Composita* in the Amsden Formation.

shoe Shale Member. Three specimens identified with question as *Torynifer setiger* Hall came from the *Carlinia amsdeniana* Subzone.

The one member of the Spiriferinidae, *Reticulariina browni* (Branson and Greger) is common in the *Carlinia amsdeniana* Subzone in Fremont County. At the only locality outside that county where it has been recorded, the containing bed was assigned to the *Composita poposiensis* Subzone.

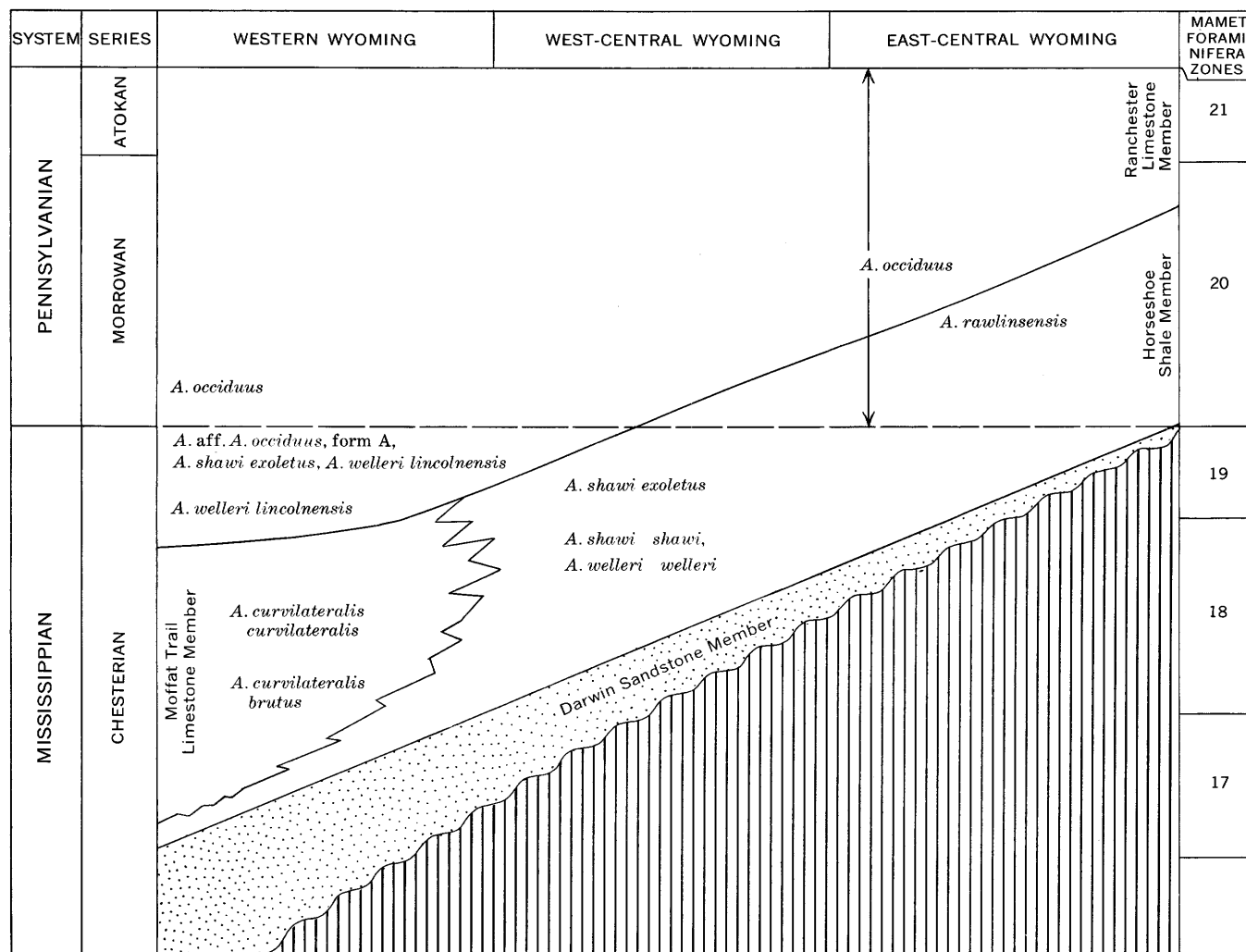
#### RETZIIDS AND TEREBRATULIDS

*Eumetria sulcata* Burk occurs in both the *Carlinia amsdeniana* and *Composita poposiensis* Subzones. It seems to be very closely related to the mid-continent species *E. costata* (Hall) and is regarded as a typical Mississippian species. Three specimens from the *Carlinia amsdeniana* Subzone are identified as *Girtyella* cf. *G. indianensis* (Girty). These are the only terebratuloids known from this basin.

#### INTERPRETATION OF FAUNAL SUCCESSION

Extension of the brachiopod zones across lithologic boundaries demonstrates rather clearly the eastward transgression of the Amsden Formation. The recognizable lithologic members of the Amsden become progressively younger eastward. The distribution of the compositas and anthracospirifers in the Amsden, shown diagrammatically in figures 1 and 2, shows this relationship, particularly with regard to the Mississippian-Pennsylvanian boundary. This transgression is discussed fully by Sando, Gordon, and Dutro (1975).

The relation of the fauna within the basin to the fauna of other basins indicates that several different periods or stages of faunal development took place. These changes in the fauna seems to be related to the tectonic and depositional history of the basin.

FIGURE 2.—Distribution of *Anthracospirifer* in the Amsden Formation.

The earliest brachiopod assemblage is found in and around the *Caninia* Zone coralline facies that stretched from western Montana southward to western Utah. The corals are widely distributed, the same few species occurring at many different localities. The brachiopods, however, are more local in distribution. Several American midcontinent species, including *Diaphragmus cestriensis* (Worthen) and *Composita subquadrata* (Hall) are present in this part of the Amsden in western Wyoming. Also present in the coralline facies or in nearby calcareous mudstones are several species common to the Heath Formation of south-central Montana, including *Diaphragmus nivosus* n. sp. and *Anthracospirifer curvilateralis* (Easton).

The fauna of the *Anthracospirifer welleri-shawi* Zone and its subzones in the Horseshoe Shale Mem-

ber in Fremont County is almost entirely endemic. Such species as *Orthotetina amsdenensis* (Branson and Greger), *Schuchertella poposiensis* (C. Branson), *Inflatia lovei* n. sp., *Carlinia amsdeniana* Gordon, *Composita sigma* n. sp., *C. poposiensis* n. sp., *Anthracospirifer welleri* (Branson and Greger), *A. shawi* n. sp., and *Reticulariina browni* (Branson and Greger) are not known outside this depositional basin. The one exception is the presence in Fremont County of the mid-continent species *Composita sulcata* Weller in the *C. poposiensis* Subzone. As this form is not known in contemporaneously deposited beds in western Wyoming or in earlier Mississippian beds in Fremont County, its sudden appearance late in the development of an endemic fauna is puzzling. Nevertheless, as *C. sulcata* has been identified in the Upper Mississippian of Idaho (Girty, 1927, p. 64)

and south-central Montana (Easton, 1962, p. 77), one can surmise that it already was living somewhere in the Wyoming depositional basin by the time the basin became isolated. The rest of the faunal evidence argues strongly for the presence of a relatively closed basin during the time span of the *Anthracospirifer welleri-shawi* Zone.

Over much of western Wyoming during this time, conditions were not particularly suitable for the development of a large and varied fauna. The Ranchester Limestone Member contains many dolomite beds in this region, and the brachiopod fauna in this member is decidedly limited in variety.

Early in Pennsylvanian time the west-central region became inhospitable to brachiopod populations. No brachiopod-bearing beds are known in Fremont County in this part of the Amsden Formation. The early Morrowan brachiopod faunas occur in two separate regions. In western Wyoming the fauna was dominated by *Eolissochonetes pseudoliratus* (Easton), *Antiquatonia blackwelderi* n. sp., *Composita ovata* Mather, and *Anthracospirifer occiduus* (Sadlick), and this fauna extended into the Idaho region. The similar fauna in east-central Wyoming contains *Antiquatonia* cf. *A. coloradoensis* (Girty) and *Linoproductus eastoni* n. sp., which are also typical of the Cameron Creek Member of the Tyler Formation and Alaska Bench Limestone of south-central Montana. This and the lithologic evidence indicate that the barrier between the Wyoming and south-central Montana basins was breached early in Morrowan time, allowing some of the faunal elements to come in.

Further links, during Morrowan and Atokan time, of the Wyoming depositional basin with basins to the east and southeast permitted the introduction to Wyoming of such midcontinent species as *Scolaconcha globosa* (Mather) and *Linoproductus planiventralis* Hoare.

In summary, the depositional and faunal successions in the Late Mississippian and Early to Middle Pennsylvanian in Wyoming involved—

1. A Mississippian brachiopod fauna of rather mixed origins in a predominantly coralliferous facies during the early stages of the transgression.
2. Development of an almost totally endemic Mississippian fauna as the transgressive locus of deposition extended farther east and the basin remained virtually closed.
3. Assembling of a Pennsylvanian fauna again of rather mixed origins as the basin began to

link up to the northeast, east, and southeast with other depositional basins.

## SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA  
Class INARTICULATA  
Order LINGULIDA  
Superfamily LINGULACEA Menke  
Family LINGULIDAE Menke  
Genus LINGULA Bruguiere, 1797  
*Lingula* cf. *L. carbonaria* Shumard

Plate 1, figures 1-3, 6

*Lingula carbonaria* Shumard, 1858, p. 215.

*Lingula* cf. *L. carbonaria* Shumard. Easton, 1962, p. 38, pl. 4, fig. 12.

*Lingula* is rare in collections from the Amsden Formation of Wyoming; our material aggregates eight specimens from four localities. Three are from limestone beds of Early Pennsylvanian (Morrowan) age in the Ranchester Limestone Member in the Gros Ventre Range, western Wyoming. These are moderate sized, the largest (pl. 1, figs. 2, 3) measuring 13.5 mm long and 8.7 mm wide. Another lot of five specimens is from siltstone of Late Mississippian age in the Horseshoe Shale Member at Wiggins Fork, Washakie Range (pl. 1, figs. 1, 6). They are smaller than the Pennsylvanian specimens, the most complete valve measuring 7.3 mm long and 4.6 mm wide. All are regarded as belonging in the same species.

The shells are elliptical, having the greatest width near the middle of the valve. Those preserved in limestone commonly have a somewhat elevated umbonal region, whereas those preserved in siltstone are nearly flat. The surface of both valves is marked by fine regular concentric striae.

These shells have the same width-length ratios as, and appear to be conspecific with, specimens identified by Easton (1962, p. 38) as *Lingula* cf. *L. carbonaria* from the Heath Formation, Cameron Creek Formation, and Alaska Bench Limestone of south-central Montana. They have somewhat less acute apical angles than examples of *L. carbonaria* figured by Dunbar and Condra (1932, pl. 1, figs. 1, 2) from the Pennsylvanian of Nebraska but agree rather closely with specimens from the Pennsylvanian rocks of Missouri identified as *L. carbonaria* by Girty (1915, p. 303), with which they have been directly compared.

*Figured specimens*.—USNM 163703A, B; 163704.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collection 46 (5), Fremont County. Ranchester Limestone Member: collections 139 (1), 141 (1), 142 (1), Teton County.

Order ACROTRETIDA  
 Suborder ACROTRETIDINA  
 Superfamily DISCINACEA Gray  
 Family DISCINIDAE Gray  
 Genus ORBICULOIDEA D'Orbigny, 1847  
*Orbiculoidea wyomingensis* Branson and Greger

Plate 1, figures 9, 11–16

*Orbiculoidea wyomingensis* Branson and Greger, 1918, p. 314, pl. 19, figs. 7, 8; C. C. Branson, 1937, p. 655, pl. 89, fig. 34; Easton, 1962, p. 39, pl. 4, fig. 13.

**Description.**—Shell of moderate size, resupinate, subcircular; length slightly greater than width. Brachial valve depressed, asymmetrically subconical; apex excentric, 35 to 45 percent of distance from posterior to anterior margin; posterior slope shallowly concave in profile; anterior and lateral slopes convex. Surface of valve nearly smooth, with very fine concentric growth lirae and some scattered coarser lirae; radial sculpture of fine striae, visible both on inner and outer surfaces of shell and strongest where shell appears partly decorticated. No internal structures seen on internal molds.

Pedicle valve shallowly convex posteriorly (concave posteriorly in lectotype probably because of crushing) and concave anteriorly. Apex excentric to subcentral; valve cleft posterior to apex by rather prominent foramen extending to within 2–3 mm of posterior margin. Surface sculpture of concentric lirae with considerably wider interspaces, of which 8 to 12 occur in space of 2 mm. Radial striae also present in pedicle valve but less visible than on brachial valve.

**Dimensions.**—Hypotype (USNM 163705) measures: length 13.3, width (not quite complete) 10.5, thickness (both valves) 4.5 mm. This is a relatively uncrushed but slightly asymmetrical specimen.

**Discussion.**—Easton (1962, p. 39) redescribed the "cotypes" (UM 2641) and designated as the "holotype" [lectotype] "the ventral valve figured by Branson and Greger (1918, pl. 19, fig. 7)." It should be added that this pedicle valve is articulated with a brachial valve, so the lectotype is actually a nearly complete specimen. Both valves of this specimen are figured here (pl. 1, figs. 14–16), as is the paralectotype (pl. 1, fig. 9), a brachial valve also illustrated by Branson and Greger (1918, pl. 19, fig. 8).

The primary types are from the *Carlinia amsdeniana* Subzone and are preserved in limonitic claystone. The specimen from the *Composita poposiensis* Subzone is partly silicified and preserved in sandstone. That this species may range up into the Lower Pennsylvanian locally is indicated by its identification by Easton (1962) in the Alaska Bench Limestone of the Big Snowy Range, Mont., from a poorly preserved specimen.

**Types.**—Lectotype and paralectotype, UM 2641; hypotype, USNM 163705.

**Occurrence and number of specimens.**—Horseshoe Shale Member: collections 36a, (2), 38 (1), Fremont County?; 146 (1) Teton County.

*Orbiculoidea* sp. A

Plate 1, figures 4, 5, 10

*Lingulodiscina* sp., Burk, 1954, p. 8, 9, pl. 1, figs. 13, 14.

Four brachial valves, collected in the Wind River Range, were described by Burk (1954) who regarded them as belonging in *Lingulodiscina*, an imperfectly understood genus of phosphatic-shelled brachiopods. The specimen with the most complete margins (IT-184) is 15.5 mm long and 15 mm (estimated) wide and 2.5 mm deep; the tip of the beak is 2.5 mm from the posterior edge. On another fragment (IT-186) the distance of the beak from the posterior edge appears to be the same. It seems reasonable to regard these as a species of *Orbiculoidea* with its apex situated close to the margin. In two specimens the apex appears marginal, but in both of them the posterior edge of the shell is broken away. In one (IT-185) the break shows that the shell is made up of 9 or 10 alternating light and dark laminae.

The shells are worn, and two of them (IT-185, 186) have shallow dendritic channeling on the surface, apparently made by some tiny organism. Local worn vestiges of concentric lirae are visible, but no radial triae or wrinkles such as are typical of *O. wyomingensis* are present.

The nearly marginal apex and absence of radial sculpture distinguish it easily from *O. wyomingensis*. I agree with Burk (1954, p. 9) that this probably is an undescribed species, but the material is not sufficient to constitute a firm basis for erecting a new name.

**Figured specimens.**—UW IT-184, 185.

**Mentioned specimen.**—UW IT-186.

**Occurrence and number of specimens.**—Horseshoe Shale Member: collection 21 (4), Fremont County.

*Orbiculoidea* sp. B

Plate 1, figures 7, 8

A brachial valve from the Ranchester Limestone Member in the Rawlins hills represents a third species of Amsden *Orbiculoidea*. It has a moderately large and deep shell with a slightly excentric umbo. The shell approximately is circular (slightly distorted by flattening along the posterior and posterolateral parts of the margin), 20.6 mm in longitudinal and transverse diameters, and 7 mm high. In lateral profile it is asymmetrical, the anterior slopes straight, becoming concave near the umbo and con-

vex posterior to it; the umbo is 9 mm from the anterior edge, and the greatest depth is approximately at the center of the valve, a little behind the umbo.

Surface sculpture consists of fine concentric lirae, about 10 of which occur in the space of 1 mm. Some of the lirae, more or less evenly spaced among the others, are coarser and some of these are dichotomous.

From *O. wyomingensis* this species is distinguished by its higher brachial valve, more centrally located umbo, coarser interspersed concentric lirae, and lack of radial striae. From *O. sp. A* the much deeper brachial valve and lack of a nearly marginal umbo are easily distinguished differences.

*Figured specimen*.—USNM 163706.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collection 3 (1), Carbon County, Ranchester Limestone Member: collection ?134 (1), Sublette County.

Class ARTICULATA  
Order ORTHIDA  
Suborder ORTHIDINA  
Superfamily ENTELETACEA Waagen  
Family ENTELETIDAE Waagen  
Genus SCHIZOPHORIA King, 1850

*Schizophoria depressa* Easton

Plate 1, figures 17–19

*Schizophoria swallowi* (Hall)? Branson and Greger, 1918, p. 312, 313, 321, pl. 19, figs. 12, 13; C. C. Branson, 1937, p. 652.

*Schizophoria depressa* Easton, 1962, p. 85, 86, pl. 4, figs. 19–23.

This species can be recognized by its broadly oval outline and its depressed cross section owing to the low convexity of the brachial valve, unusual in this genus. The hinge line is moderately long, equal to about three-quarters the length and almost three-fifths the width of the shell in the specimen figured; the cardinal angles are broadly obtuse, the hinge meeting the posterolateral margins of the shell at an angle of approximately  $140^\circ$  in the same specimen. About 18 radial lirae occur in the space of 5 mm on the anterior slope near the margin. Easton has described this species in detail, and the reader is referred to his paper for further information.

The figured specimen has the following measurements (in mm): length 12.2, width 16.5, thickness 7.6, depth of pedicle valve 3.2, depth of brachial valve 5.1, length of hinge 9.5, height of interarea in pedicle valve 1.7, and in brachial valve 1.1 mm.

*S. depressa* is rare in the Amsden Formation, but occurs in beds both of Late Mississippian and Early Pennsylvanian age. Easton (1962, p. 85) placed in synonymy with this species the specimen from

Cherry Creek illustrated by Branson and Greger (1918, pl. 19, figs. 12, 13) as *S. swallowi*?. This is an iron-stained calcareous specimen and probably came from the *Carlinia amsdeniana* subzone. Our specimen illustrated on plate 1 is from Livingston Ranch and came from the same subzone. Easton's Montana specimens were collected from beds of both Late Mississippian and Early Pennsylvanian age, but the holotype is from the Mississippian Heath Formation.

*Figured specimen*.—USNM 163707.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 36a (1), 45 (3), Fremont County; 41 (2), Teton County. Ranchester Limestone Member: collections 63 (2), Sheridan County; 100 (8), Lincoln County.

*Schizophoria aff S. texana* Girty

Plate 1, figures 26–30, 40, 41

*Description*.—Shell inflated, resupinate; plane of commissure indented anteriorly by broad rounded sulcus; no corresponding fold identifiable. Pedicle valve subcircular to transversely suboval in outline, tending toward subpentagonal; greatest width a little anterior to midlength; convex in side profile, curvature greatest at beak and gradually lessening anteriorly; broadly convex in posterior profile with straighter sloping sides, slightly flattened over middle. Sulcus beginning approximately at midlength, broad and shallow anteriorly. Hinge roughly half as wide as valve; cardinal extremities forming obtuse angles. Interarea broadly triangular, inclined at roughly  $150^\circ$  to plane of commissure, approximately four times wider than high, concave in side profile, and pierced medianly by triangular delthyrium. Surface sculpture consisting of delicate capillae having subequal or slightly wider interspaces; 25 to 28 capillae occurring in space of 5 mm near anterior margin of shell. Concentric sculpture of several fairly prominent grooves, largely confined to anterior half of shell, representing brief interruptions in growth.

Interior of pedicle valve having pair of dental lamellae diverging very slightly and bounding outer sides of rather narrow delthyrial chamber; muscle-scar field bisected by moderate-sized median septum. Sculptured anteriorly and laterally by prominent dendritic vascular grooves. Slightly denticulate along margin corresponding to capillae and interspaces of exterior surface.

Brachial valve deeper than pedicle one, strongly convex subcircular to broadly oval in outline; fold not differentiated from rest of valve. Umbonal region inflated; beak strongly incurved and overhang-



ing hinge slightly. Interarea wide, shallow, concave. Sculpture similar to that of pedicle valve, but some capillae appearing larger than others spaced at fairly regular intervals.

Interior of brachial valve having notothyral chamber bordered posterolaterally by brachiophore bases that diverge at angle of  $75^\circ$ ; muscle-scar field bisected by narrow sharp median ridge. Margin of valve denticulate.

*Dimensions*.—Illustrated specimen measures (in mm): length 15.5, width 19.1, thickness 12.2, depth of pedicle valve 5.5, depth of brachial valve 8.8, width of hinge 9.0, height of interarea in pedicle valve 2.2, and in brachial valve 1.5.

*Discussion*.—As pointed out by Girty (1927, p. 433) a marked efflorescence of *Schizophoria* seems to have taken place in Early Pennsylvanian time. At least six species are known in Lower Pennsylvanian rocks in the American midcontinent and west: *Schizophoria altirostris* (Mather), *S. depressa* Easton, *S. oklahomae* Dunbar and Condra, *S. resupinoides* (Cox), *S. schucherti* (Girty), and *S. texana* Girty. Actually this flowering of schizophorian species began in the latter part of the Late Mississippian species began in the latter part of the Late Mississippian as *S. depressa*, *S. cf. S. resupinoides*, and forms related to *S. texana* are locally abundant in upper Chesterian rocks in the Rocky Mountain and Great Basin regions.

The Amsden species under consideration is somewhat like *S. texana* but differs from it in having a more convex pedicle valve with a more highly inclined interarea and incurved overhanging beak, and finer sculpture. These differences are even more accentuated when one compares the Amsden form with *S. altirostris* from the type Morrowan section in northwestern Arkansas. Mather's species has a much flatter pedicle valve, the median sulcus already strongly developed at midlength in average specimens, markedly angular cardinal extremities, and a nearly flat interarea inclined at roughly  $110^\circ$  to the plane of commissure. The brachial valve is more highly arched transversely in *S. altirostris*, the umbonal region narrower and more elevated, and the flanks more obliquely planate. This species is easily distinguished from *S. depressa* Easton by its less transverse outline and much more convex brachial valve.

This Amsden species is very close to the form that occurs in the Great Basin in western Utah and eastern Nevada in the same part of the section. There is very little difference in shape; however, Utah shells reach 23 mm in length and have slightly

coarser sculpture, 15 to 19 capillae occurring in the space of 5 mm in the middle of the anterior slope. It seems likely that the western form is a distinct species, the Amsden specimens representing a subspecies of the Great Basin shells. In my opinion, the Great Basin species should be named first in order that more abundant and well-preserved specimens from a number of localities can be studied and serve as a basis for this taxon. For this reason I am not introducing a name at this time for the Amsden shells.

*Figured specimen*.—USNM 163713–163715.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collection 45 (2), Fremont County. Ranchester Limestone Member: collections 13 (10) Carbon County; 67 (30), 68 (1), Sheridan County; 141 (2), Teton County.

Family RHIPIDOMELLIDAE Schuchert  
Genus RHIPIDOMELLA Oehlert, 1890

*Rhipidomella carbonaria* (Swallow)

Plate 1, figures 20–25

*Orthis carbonaria* Swallow, in Shumard and Swallow, 1858, p. 218; Meek, 1872, p. 173, pl. 1, figs. 8a–c; Meek and Worthen, 1873, p. 571, pl. 25, fig. 4; Hall, 1883, pl. (7) 37, figs. 1–4.

*Orthis pecosi* White (not Marcou), 1877, p. 125, pl. 9, figs. 5a–e; 1884, p. 129, pl. 32, figs. 20–22; Hall and Clarke, 1892, pl. 7, figs. 1–4; Keyes, 1894 [1895], p. 64; Smith, p. 237; 1897, p. 27.

*Rhipidomella pecosi* (White). Beede, 1900, p. 96; Girty, 1903, p. 344; Woodruff, 1906, p. 279, pl. 10, fig. 4; Mark, 1912, p. 303, pl. 13, fig. 10; Mather, 1915, p. 144, pl. 8, figs. 3–3a; Morningstar, 1922, p. 175, pl. 7, fig. 13.

*Rhipidomella carbonaria* (Swallow). King, 1930, p. 43; Dunbar and Condra, 1932, p. 52, pl. 2, figs. 1–4; Cooper, in Shimer and Shrock, 1944, p. 355, pl. 139, figs. 24–26; Plummer, 1950, pl. 19, figs. 1a, b; Gehrig, 1958, p. 10, pl. 6, figs. 39–41; Hoare, 1961, p. 26, 27, pl. 1, figs. 10–12; Sturgeon and Hoare, 1968, p. 25, pl. 2, figs. 13, 14.

*Description*.—Shell biconvex, pentagonally sub-circular in outline; greatest width slightly anterior to middle; greatest thickness posterior to middle; hinge line equal to slightly less than half maximum thickness of shell. Pedicle valve less convex than brachial; beak moderately incurved over interarea. Interarea slightly wider than high, nearly flat but slightly concave in side profile; delthyrium moderately large, triangular with apical angle of about  $55^\circ$ , open, occupying roughly two-fifths of interarea. Surface sculpture parvicostellate; costellae uneven, increasing by intercalation, about 16 occurring in space of 5 mm on anterior slope near margin. Shell minutely punctate.

Pedicle interior with strong dental lamellae forming supports for teeth. Adductor muscle-scar plat-

form elongate, elevated, nearly flat on top, located on floor of valve at base of slope beginning about 2 mm in from umbo, in middle of depressed rounded-subtriangular diductor muscle-scar field and dying out at anterior end of this field; two small narrow closely spaced depressions near posterior end of adductor muscle-scar platform diverge posteriorly. Anterior and lateral margins of valve radically grooved internally.

Brachial valve moderately convex; greatest convexity near umbo; greatest depth near middle, and sloping toward margins. Interarea small, nearly flat, rudely crescent-shaped; notothyrium bordered by chilidium consisting of pair of nearly erect triangular plates diverging at angle of approximately  $55^\circ$ . Surface sculpture of brachial valve same as on pedicle valve.

Interior of brachial valve with triangular cardinal process thrust between chilidial plates, set on large swollen posterior platform; process composed of short shaft supporting grooved myophore; posterior surface of myophore sloping anteriorly, generally marked by two prominent grooves and various finer lamellae; in some specimens short median groove separates above-mentioned two grooves anteriorly. Sides of cardinal process extend anterolaterally into brachiophores, also diverging at  $55^\circ$  angle, supported on floor of valve by base plates; hinge sockets occur between brachiophores and margin of valve at extremities of interarea. Median ridge, low and rounded, extends anteriorly from posterior platform, bisecting four muscle-scar depressions, a shallow and short posterior pair and a deep and subcircular anterior pair. Margins of valve radially grooved internally as in pedicle valve.

*Dimensions*.—Figured complete specimen (pl. 1, figs. 22, 25) measures: length 11.5, width 11.8, thickness 6.1, depth of pedicle valve 2.4, depth of brachial valve 3.2, length of hinge 4.5, height of interarea in pedicle valve 1.0, and in brachial valve 0.6 mm.

*Discussion*.—All the Pennsylvanian rhipidomellas have been put in a single species for which the synonymy is given above. Comparison with specimens in the USNM collection shows some slight differences between the Wyoming specimens of Early Pennsylvanian age and specimens from the Finis Shale of Texas of Late Pennsylvanian age. The Finis Shale specimens are smaller, have a narrower interarea in the brachial valve, and a more delicate cardinal process. The Wyoming specimens seem to be identical with specimens of Early Pennsylvanian

age from the Marble Falls Limestone near San Saba, Tex.

This species is known in the Amsden Formation from a limestone bed in the Moffat Trail section, approximately 175 feet above the top of the Darwin Sandstone Member. It is the dominant fossil and only brachiopod in this bed.

*Figured specimens*.—USNM 163716–163718.

*Occurrence and number of specimens*.—Ranchester Limestone Member: collections 86 (12), 85 (18), Lincoln County.

Order STROPHOMENIDA  
Suborder STROPHOMENIDINA  
Superfamily DAVIDSONIACEA King  
Family MEEKELLIDAE Stehli  
Genus ORTHOTETINA Schellwien, 1900

*Orthotetina amsdenensis* (Branson and Greger)

Plate 2, figures 1–3, 7; text figure 3B

*Meekella amsdenensis* Branson and Greger, 1918, p. 318, pl. 18, figs. 22–25.

*Diagnosis*.—Nonplicate meekellid of moderate size bearing fine parvi- to multicostellate ornamentation averaging  $3\frac{1}{2}$  costellae in the space of 1 mm. Interarea slightly concave,  $2\frac{1}{2}$  times wider than high, having wide perideltidium.

*Description*.—Shell biconvex, in some specimens approaching resupinate in shape. Pedicle valve strongly convex posteriorly, less convex anteriorly; anterior and lateral slopes less convex and moderately inclined. Greatest width near middle of valve; lateral margins curving toward interarea posteriorly. Shallow medial sulcus present in anterior part in some specimens (squeezed into deep irregular trough in lectotype by distortion after burial). Interarea concave in side profile, its height equal to approximately two-fifths its width, inclination to plane of commissure varying from  $100^\circ$  (in lectotype) to  $170^\circ$  (in figured paralectotype). Pseudodeltidium occupying one quarter, or slightly more, of width of interarea, its sides (determined in several specimens) diverging forward at angles of from  $20^\circ$  to  $25^\circ$ ; perideltidium wide, its outer edge approaching to within  $1\frac{1}{2}$  to 2 mm of sides of interarea anteriorly. Umbo excentric, flattened posteriorly, and gently incurved.

Pedicle valve sculptured by fine capillae, which increase by intercalation; normally 16 to 18 capillae occur in space of 5 mm; intercostal grooves generally wider than capillae. Radial sculpture crossed by finer concentric lirae.

Interior of palintrope of pedicle valve bearing two nearly parallel dental plates that extend forward along floor of valve to about one-half its length;

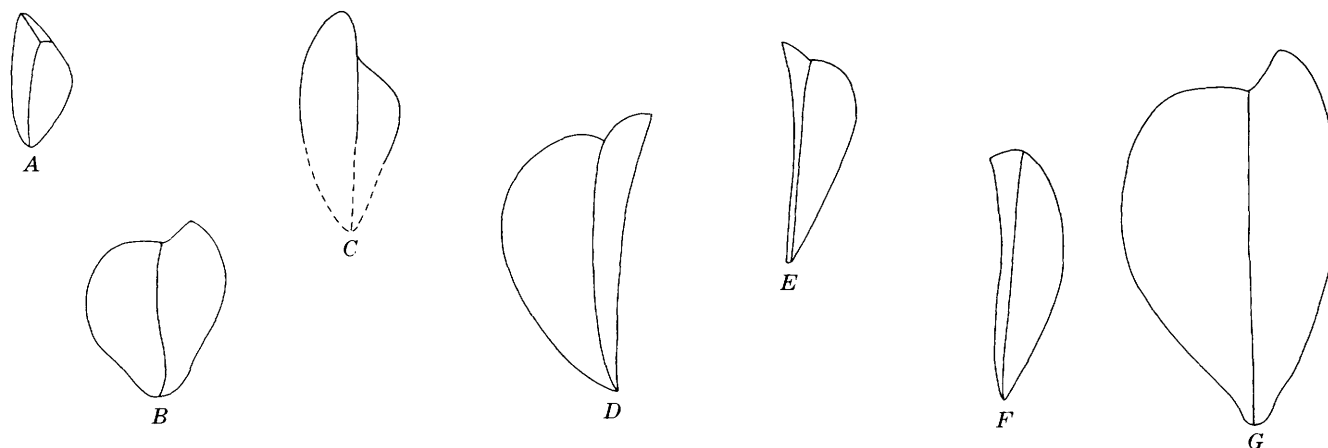


FIGURE 3.—Profiles of orthotetoid brachiopods in the Amsden Formation (all natural size). A, *Schuchertella poposiensis* (C. Branson). B, *Orthotetina amsdenensis* (Branson and Greger). C, *Pulsia* sp. A. D, *P. delira* n. sp. E, *Orthotetes* sp. A. F, *O. kaskaskiensis bransonorum* n. subsp. G, *Derbyia* cf. *D. robusta* (Hall).

these are 0.8 mm apart posteriorly and 1.5 mm apart at their anterior ends.

Brachial valve convex, more strongly so than pedicle valve, greatest convexity near hinge line; outline subcircular. Surface sculpture approximately same as on pedicle valve. Details of cardinal process not exposed in primary types, but rather strong pair of chilidial plates present in one paralectotype (pl. 2, fig. 7). Cardinal process supported within brachial valve by pair of rather straight socket plates, diverging at angle of  $55^{\circ}$  and extending to points 11 mm from center of hinge line. Between these plates, subtriangular muscle field is rudely flabellate radially, bisected by shallow narrow median ridge.

*Dimensions (in mm).—*

|                               | Lectotype | Paralectotype    |
|-------------------------------|-----------|------------------|
| Length .....                  | 23        | 29½              |
| Maximum width .....           | 23½       | <sup>1</sup> 31½ |
| Thickness (both valves) ..... | 16        | 9.2              |
| Height of interarea .....     | 5         | 7½               |
| Width of interarea .....      | 12        | 19               |

<sup>1</sup> Twice the half width.

Branson and Greger's syntypes consist of three specimens in the collection of the University of Missouri Museum of Geology, catalog No. 2643. Of these, the specimen figured by Branson and Greger (1918, pl. 18, figs. 23, 24) is hereby designated the lectotype. This specimen is the one figured by Branson and Greger (1918, pl. 18, fig. 22) at a slightly greater diameter than actual. The other specimen figured by Branson and Greger (1918, pl. 18, fig. 25) and a less complete unfigured specimen in the same lot are paralectotypes. A previously unrecorded incomplete shell from 20 miles south of Lander is UM 10891.

This distinctive species is the only nonplicate "*Meekella*" known in the United States. *Meekella*

*striaticostata* (Cox) the long-ranging and widespread plicate species, has been reported from the Upper Mississippian Redoak Hollow Formation of Oklahoma by Elias (1957, p. 493, 494, pl. 52, fig. 5). *M. striaticostata* also occurs in limestone of late Chesterian age in the subsurface of the Black Warrior basin in northern Mississippi.

The Amsden species closest to *Orthotetina amsdenensis* is the one described in this paper as *Pulsia* sp., which differs principally in having a less tumid shell with much shorter, more widely spaced dental plates in the pedicle valve and slightly coarser sculpture.

*Types*.—Lectotype and paralectotypes, UM 2643.

*Occurrence and number of specimens*.—Horseshoe Shale Member, collections 27 (2), 36a (2), 36b (3), 36c (1), Fremont County.

**Genus PULSIA Ivanov, 1925**

*Pulsia* Ivanov, 1925, p. 113.

*Schellwienella* (*Pulsia*) Ivanov. Muir-Wood and Williams, in Moore, 1965, p. H407.

*Description*.—Shell medium-sized to large, resembling *Derbyia*. Pedicle valve almost flat, having low broad interarea and rather narrow delthyrium. Brachial valve strongly convex. Both valves bearing surface sculpture of costellae and capillae increasing by intercalation. Within palitrope a pair of high thin dental plates connects margins of delthyrium with floor of valve, extending forward and dying out gradually along floor at either side of elongate oval cavity, anterior margin of which is marked by narrow shoulder slightly raised above floor of valve; this scooplike structure may reach lengths of 20 to 25 mm in large specimens; dental plates meet and fuse at apex of delthyrium. Muscle scars located on floor of structure, marked by faint pinnate pattern;

muscle field intersected by three elongate ridges and in some specimens two additional faint ridges. Interior of brachial valve imperfectly known. Cardinal process fairly short, less than half the height of the delthyrium, four-lobed.

*Type species.*—*Pulsia mosquensis* Ivanov, 1925.

The description above is based on Ivanov's original description as translated from the Russian by Josephine Cooper, but has been rearranged and slightly altered. Ivanov pointed out that the unity of the scooplike structure of which the dental plates are a part is accentuated by the fact that the floor of the valve between the plates is thickened and somewhat elevated above the rest of the surface and also is covered by a porcellaneous substance identical in appearance to that composing the plates.

Muir-Wood and Williams (in Moore, 1965, p. H407) regarded *Pulsia* as a subgenus of *Schellwienella*, but there is reason to regard them as separate genera. *Pulsia* possesses true dental plates, resembling those in *Meekella*, but shorter. The so-called dental plates in *Schellwienella*, which diverge much more widely and border a prominent, rather deeply impressed muscle-scar field seem to be composed only of secondary shell material. G. A. Cooper (oral commun., 1968) has suggested that for this reason *Schellwienella* may be closely related to *Schuchertella*, perhaps even congeneric.

The genus *Pulsia* is recognized here for the first time in North America, by two species, both of them older than those described by Ivanov from the Moscow Basin. *Pulsia delira* n. sp. is from beds of Pennsylvanian (Morrowan or Atokan) age. *Pulsia* sp. A occurs in rocks of late Chesterian age. The presence in U.S. Geological Survey collections from the Boone Formation of Oklahoma, Missouri, and Arkansas of an undescribed species showing incipient structures within the palintrope that resemble those of *Pulsia* suggest that this genus may actually have had its origins in the American midcontinent.

*Pulsia delira* n. sp.

Plate 2, figures 22–26, 32; text figure 3D.

*Diagnosis.*—*Pulsia* with convexo-concave shell having relatively low interarea inclined at angles of 85° to 95° to plane of commissure. Ornamentation multicostellate, about three capillae occurring in space 1 mm.

*Description.*—Shell shallowly convexo-concave. Pedicle valve concave posteriorly, nearly flat anteriorly, gently convex in areas of cardinal extremities, subcircular to transversely suboval in plan, with well-rounded lateral margins; greatest width approximately at middle of valve. Posterior margins

of valve form obtuse angle with lateral margins at cardinal extremities. Apex low; apical angle roughly 160°; interarea broad, nearly flat, its height slightly more than one-fifth its width, tilted in holotype at angles of 100° to plane of commissure and 75° to plane of pedicle valve; same angles in paratype, 95° and 65°, respectively. Triangular delthyrium closed by pseudodeltidium, its apical angle 27° in holotype.

Pedicle valve sculptured by fine closely spaced costellae, with slightly narrower intercostal sulci, increasing by intercalation, appearing multicostellate on fragment of external mold. Normally 13 to 15 capillae occur in space of 5 mm. Concentric sculpture limited to very sparsely distributed growth furrows and swellings.

Interior of pedicle valve has pair of slightly diverging dental plates extending from sides of delthyrium to floor of valve, where they are 8 to 9 mm long, spaced about 2 mm apart near apex of valve and 3½ to 4 mm apart at their anterior ends; plates cut smooth subcircular area on floor of valve, about 10 mm in diameter; anterior edges of dental plates concave.

Brachial valve deeply convex, suboval, much wider than long, strongly inflated in posterior part, with greatest curvature near cardinal process and decreasing gradually toward anterior margin; lateral slopes fairly steeply inclined. Surface sculpture of valve as on pedicle valve; along anterior margin in figured specimen (USNM 163724) 20 to 21 capillae occur in space of 5 mm.

Interior of brachial valve posteriorly with pair of broadly diverging socket plates, about 9 mm long, bounding adductor muscle field, which is bisected by weak narrow ridge; socket plates spaced about 5 mm apart at base of cardinal process and 10 mm apart at their anterior ends. Cardinal process fairly broad, gently curved; details not preserved in this material.

*Dimension (in mm).—*

|                             | <i>Pedicle valves</i> |                             | <i>Brachial valve</i> |
|-----------------------------|-----------------------|-----------------------------|-----------------------|
|                             | USNM<br>163722        | USNM <sup>1</sup><br>163721 | USNM<br>163724        |
| Length of valve .....       | 36                    | 33                          | 26                    |
| Length along curvature ---- | 37                    | 34                          | 41                    |
| Maximum width .....         | <sup>2</sup> 44       | 47                          | 36                    |
| Width of interarea .....    | <sup>2</sup> 35       | 33                          | —                     |
| Height of interarea .....   | 7½                    | 7                           | —                     |
| Depth of valve .....        | 7                     | 6½                          | 21                    |

<sup>1</sup> Holotype.

<sup>2</sup> Twice the half width.

*Discussion.*—The description above is based mainly on two nearly complete internal molds of the pedicle valve from a chert bed near the top of the Amsden Formation and one of a brachial valve from

the same bed at approximately the same locality. Because they were not found in articulation nor even in the same collection, the possibility exists that the brachial and pedicle valves do not belong to the same species, but the typically schellwienellid arrangement of the socket plates in the brachial valve and the similarity of the sculpture pattern in both valves make that possibility highly unlikely. A reconstruction of the two valves in articulation is shown in figure 3D. The holotype bears a few poorly defined radial swellings which are absent on the paratype and therefore considered pathologic.

*Pulsia delira* is distinguished by its striking convex-concave shape from all the other davidsoniacean strophomenoid brachiopods in the Amsden Formation, with the possible exception of *Derbyia* cf. *D. robusta* Hall. The *Derbyia* can be distinguished, however, by its less inflated brachial valve and by the presence of a media septum in the pedicle valve.

The pair of slightly diverging dental plates that reach the floor of the pedicle valve and the rather evenly fine radial shell sculpture ally *Pulsia delira* with *Orthotetina amsdenensis* (Branson and Greger). *O. amsdenensis* has, however, a narrow irregularly biconvex shell with a high steeply inclined and shallowly concave interarea and a long closely spaced parallel pair of dental plates, by which it can easily be distinguished from *P. delira*.

*Stratigraphic considerations.*—The stratigraphic position of *P. delira* near the top of the Amsden Formation in eastern Wyoming as well as its associated faunule show that this species is part of the Pennsylvanian fauna.

*Types.*—Holotype, USNM 163721; paratypes, USNM 163722–163724.

*Occurrence and number of specimens.*—Ranchester Limestone Member: collection 52 (4), Johnson County.

#### *Pulsia* sp. A

Plate 2, figures 4–6; text figure 3C

Three incomplete specimens from the Moffat Trail and Covey Cutoff sections are referred to *Pulsia* and represent a different and earlier species than the one from the Ranchester in north-central Wyoming. As the anterior parts of all three specimens are missing it is not possible to tell whether the shells are biconvex or resupinate. One of them, retaining parts of both valves, is figured (pl. 2, figs. 4–6).

The ventral valve is gently convex, at least in the posterior part, and appears roughly subcircular to

transversely oval, the greatest width probably occurring near the middle of the valve. The interarea is steep, gently concave in longitudinal profile, and lies nearly in the plane of commissure. It is relatively narrow and moderately high, with an apical angle of roughly 120°; the delthyrium is narrow with apical angles in two specimens of 12° and 17°, covered by a raised pseudodeltidium. The perideltidium, seen faintly in an unfigured specimen, extends from the apex of the interarea to points about halfway from the edge of the pseudodeltidium to the end of the interarea at either side.

Dental plates, diverging slightly and discernible in all three specimens, extend from the apex along the sides of the delthyrium and connect with the floor of the valve. In the figured specimen they are 4½ mm long and 3 mm apart at their anterior ends; in the unfigured ones, 5.2 and 6.5 mm long and 3 and 3½ mm apart, respectively.

The brachial valve is convex, rather gently so near the umbo, the greatest convexity occurring, so far as can be determined, posterior to the middle of the valve, which slopes off in all directions to the margins. Internal structures of the brachial valve were not seen.

Surface sculpture in both valves is multicostellate, resembling that of *Pulsia delira* n. sp., 13 to 16 capillae occurring in a space of 5 mm on the more anterior parts of the valves.

The figured specimen is 21½ mm long (with perhaps two-fifths of the length missing), 30 mm wide, and 10½ mm thick (both valves). The interarea in the pedicle valve is 22 mm wide and 4½ mm high. On one of the unfigured specimens, the interarea is 19 mm (twice the half width) and 5 mm high.

This species is distinguished from *Pulsia delira* n. sp. by its more convex pedicle valve, having a narrower, more steeply tilted interarea and shorter dental plates, and the less inflated brachial valve. From *Orthotetina amsdenensis* it is distinguished by its less tumid shell with a wider lower interarea in the pedicle valve and shorter diverging dental plates.

The stratigraphic position of this species, together with its associated fossils, demonstrate that the beds that contain it are Chesterian in age.

*Figured specimen.*—USNM 163719.

*Mentioned specimen.*—USNM 163720.

*Occurrence and number of specimens.*—Moffat Trail Limestone Member: collection 72 (2), Lincoln County. Ranchester Limestone Member: collection 95 (1), Lincoln County.

## Family SCHUCHERTELLIDAE Williams

Genus SCHUCHERTELLA Girty, 1904

*Schuchertella poposiensis* (C. Branson)

Plate 1, figures 51, 53; plate 2, figures 8–10, 12–17; text figure 3A.

*Streptorhynchus poposiensis* C. Branson, 1937, p. 655, pl. 89, figs. 10–12.

**Diagnosis.**—Small biconvex *Schuchertella*, subcircular in outline; interarea three times wider than high; parvicostellate sculpture. Brachial valve shallowly to moderately convex.

**Description.**—Pedicel valve gently convex, slightly wider than long; greatest width just anterior to middle of valve; lateral margins curving inward posteriorly to meet shorter hinge line; posterior margins fairly straight; apical angle ranging from 120° to 130°. Interarea flat, inclined at angle ranging from 130° to 140° to plane of commissure; height of interarea approximately one-third its width; delthyrium covered by pseudodeltidium occupying about one-fifth of interarea, its sides diverging anteriorly at 30° angle; perideltidium moderately narrow.

Surface of pedicel valve covered by narrowly rounded to subacute costellae separated by subequal to narrower intercostal sulci. Fine intercalating threads at intervals between coarser costellae give parvicostellate appearance to ornamentation; 10 to 14 costellae occur in space of 5 mm on anterior and lateral slopes of valve. Radial sculpture crossed by very fine concentric growth lirae. Interior of pedicel valve with delthyrium bordered by dental ridges.

Brachial valve moderately convex, flat near umbo, greatest curvature just posterior to middle, gently convex on anterior and lateral slopes; anterior third with shallow median sulcus. Surface sculpture approximately as on pedicel valve. Interior of brachial valve not known.

**Dimensions (in mm).—**

|                               | USNM<br>163725 | USNM<br>163726   |
|-------------------------------|----------------|------------------|
| Length .....                  | 17.5           | 15.2             |
| Maximum width .....           | 18.5           | 16.3             |
| Thickness (both valves) ..... | 8              | <sup>1</sup> 6.5 |
| Height of interarea .....     | 4.3            | 4.4              |
| Width of interarea .....      | 13             | 13               |

<sup>1</sup> Slightly crushed.

**Discussion.**—The diagnosis and description given above are based upon two specimens in the U.S. National Museum collected by I. A. Keyte from the Amsden Formation at an unknown locality near Lander, Wyo. Branson's type specimens came from the Little Popo Agie River, roughly 15 miles south of Lander, and were tiny immature examples found with ostracodes collected by P. S. Morey in 1932. The

largest of these is a paratype (UM 6833) 3.8 mm long; the holotype is 1.0 mm wide. The writer is convinced that Keyte's specimens represent the adult stage of Branson's species, despite some minor disagreement between Branson's description and his.

Branson's statement, for example, that the pedicel valve is "twice as wide as long" does not fit any of the specimens. Branson's figures, as well as his type specimens, show that the length of the shell in this immature stage ranges from two-thirds to four-fifths the width. These proportions are approximated in the apical part of Keyte's specimens. The interarea shown in one of the immature specimens figured by Branson (1937, pl. 89, fig. 12) has a height equivalent to 36 percent of the width of the interarea, compared with 33 percent in both of Keyte's adult specimens. Direct comparison of Branson's types with Keyte's specimens also shows that the sculpture pattern is the same.

Branson described this species as a *Streptorhynchus* and the shape of the Fremont County specimens approaches that genus. The writer, however, has identified as *Schuchertella* cf. *S. poposiensis*, specimens from Carbon County, Mont., a little north of the State line, on the west flank of the Bighorn Mountains. These are incomplete silicified valves that on etching show typical internal characters of *Schuchertella*. The pedicel valve of this form, its internal structures limited to dental ridges at either side of the delthyrium, appears almost identical externally with that of the material from near Lander, but the brachial valve is flatter. The cardinal process and its supporting socket plates are typical of the genus *Schuchertella*. The socket plates are short and diverge laterally, where they are recurved toward the posterior margin (pl. 1, fig. 51).

*Schuchertella poposiensis* is the smallest of the Amsden davidsoniacean strophomenoids and can also be distinguished by its rather narrowly biconvex shell and subcircular outline with its obtusely angular apex. The only two shells likely to be confused superficially with it are *Orthotetina amsdenensis* (Branson and Greger) and *Pulsia* sp. A. The *Orthotetina* is normally a more tumid species, less regular in shape, having a higher concave interarea with a much wider perideltidium. The *Pulsia* is also somewhat irregular and has a narrow, somewhat concave interarea. Both species are equipped with a pair of dental plates, lacking in *S. poposiensis*.

**Types.**—Holotype, UM 6598; paratypes (labeled "cotype," "metatypes," and paratype), UM 6596, 6614, 6615, 6833 (5 specimens); hypotypes, USNM 163725, 163726.

*Figured specimens.*—(*Schuchertella* cf. *S. popo-siensis*) USNM 163709, 163727, 163739, 163740.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 36d, (6), E (2), Fremont County; collection 69 (cf) (3), Carbon County.

Family ORTHOTETIDAE Waagen  
Genus ORTHOTETES Fischer de Waldheim, 1829

*Orthotetes kaskaskiensis* bransonorum n. subsp.

Plate 1, figure 54; plate 2, figures 27–29; text figure 3F.

*Orthotetes kaskaskiensis* (McChesney). Branson and Greger, 1918, p. 314, pl. 19, figs. 3, 4.

?*Orthotetes*? sp. Burk, 1954, p. 9, pl. 1, fig. 1.

*Orthotetes* (*Orthotetes*) sp. Easton [part], 1962, p. 42, 43, pl. 5, figs. 1–4 [not fig. 5].

*Diagnosis.*—Like *Orthotetes kaskaskiensis* (McChesney) but differing from typical form in having markedly parvicostellate ornamentation, averaging two costellae in space of 1 mm, and lesser convexity of brachial valve.

*Description.*—Shell resupinate to shallowly convexo-concave; umbonal region gently convex. Pedicle valve transversely suboval in outline; greatest width near midlength. Posterior margins nearly straight to slightly concave; apical angle ranging from 115° to 145°. Interarea rather wide, in some shells approaching but not equaling greatest width, low, generally sloping about 125° to plane of commissure, but reaching 90° (in holotype); perideltidium occupies roughly half of width of interarea; delthyrium, about one-eighth of width of interarea, its sides diverging toward anterior edge at angle of about 35°. Surface of valve covered with radiating costellae of different ranks added solely by intercalation in parvicostellate arrangement; 17 to 22 costellae occur in space of 10.0 mm in anterior parts of shell. Intercoastal sulci wider than costellae. Radial sculpture crossed by fine concentric lirae.

Interior of pedicle valve with prominent median septum in posterior third of shell; septum unites with pair of stout dental plates that extend forward and toward it from margins of delthyrium, forming small subtriangular spondylium within umbo.

Brachial valve gently convex, except for pair of subtriangular gently concave areas near hinge, one at either side of umbonal region; greatest convexity near middle of valve; sloping toward margins. Surface ornamentation like that of pedicle valve. Cardinal process bifid, each lobe with a deep longitudinal groove, lobes uniting anteriorly; process set off by pair of chilidial plates.

Two specimens (holotype and paratype) collected by Branson and Greger measure (in mm); length

31 and 32, width 43 and 38, thickness 8 and 10, respectively.

*Discussion.*—This new subspecies is erected to contain Late Mississippian (Chesterian) specimens of *Orthotetes* from the Rocky Mountain region that differ from the typical form in having a decidedly parvicostellate arrangement of the costellae. Specimens from the American midcontinent from rocks of both Meramecian and Chesterian age have a surface sculpture that is considerably more multicostellate in aspect. The costellae of these shells are inserted by intercalation; they tend to increase in size rapidly and attain the approximate strength of earlier costellae. Near the shell margins it is virtually impossible to distinguish between different ranks of intercalary costellae by strength alone. Comparing shells from the two regions, those from the Rocky Mountain region appear to be more coarsely or sparsely costellate, but this is largely an illusion produced by the parvicostellate arrangement of surface sculpture on the western form. If one counts the very fine intercalaries as well as the coarser costellae on the western shells, the number per unit measurement is seen to be approximately the same as on the typical form, on which all of the costellae tend to be strong and the interspaces narrow. The more convex brachial valves of the typical *O. kaskaskiensis* have their greatest convexity about one-quarter to one-third of the way forward from the posterior margin of the valve.

The type specimens of this subspecies are from Cherry Creek in the Wind River Range. The holotype is the specimen (UM 2662a) figured by Branson and Greger (1918, pl. 18, fig. 4) as *O. kaskaskiensis* (McChesney), and one of the paratypes is the shell (UM 2662b) from which they figured the interarea (Branson and Greger, 1918, pl. p. 18, fig. 3). Two additional incomplete shells in the U.S. Geological Survey collection, presented by Carl Branson, are also designated as paratypes and illustrated on plate 1, figure 54 and plate 2, figure 29.

This subspecies is very common at Berry Creek in the Teton Range where its shells form a mat in some shale beds. Unfortunately, these layers which locally are almost coquinoïd have not yielded well-preserved and complete specimens. Beaks of pedicle valves that have been ground down expose the spondylium partly filled with secondary shell material.

A pedicle valve from Horse Creek in the Wind River Mountains, apparently distorted or aberrant because it is convex throughout, was described and figured by Burk (1954, p. 9, pl. 1, fig. 1) as *Orthotetes*? sp. Someone has ground down the sur-



face slightly in the area of the beak, disclosing a rather strong median septum, which appears to be inserted at the umbo between two short darker colored plates. The grinding did not progress far enough to determine if a spondylium is present. As the details of the interarea resemble those of *O. kaskaskiensis bransonorum* and remains of the sculpture show that the surface has ornamentation closely resembling that of this species, Burk's specimen is placed, but still with some question, in the synonymy of this subspecies.

Shells from the Otter and Heath Formations in central Montana, described and figured by Easton (1962) as *Orthotetes* (*Orthotetes*) sp., also are referred to this subspecies.

*Types*.—Holotype, US 2642a; paratypes, UM 2642b, USNM 163728, 163729.

*Occurrence and number of specimens*.—Moffat Trail Limestone Member: collection 120 (5), Teton County. Horseshoe Shale Member: collections 27 (2 fragments), ?31 (1), 36a (2 fragments), 43 (1), ?45 (2), ?47 (2), Fremont County; ?149 (15), ?151 (fragments), 152 (6), 153 (10), ?155 (3), 156 (1), 157 (4), ?158 (1), Teton County.

#### *Orthotetes* sp. A

Plate 2, figures 19–21; text figure 3E

*Orthotetes* (*Orthotetes*) sp. Easton [part], 1962, p. 42, 43, pl. 5, fig. 5 [not figs. 1–4].

*Orthotetes* (*Derbyia*) sp. Easton [part?], 1962, p. 43 [?not pl. 4, figs. 17, 30].

*Description*.—Shell shallowly convexo-concave, subcircular in plan. Pedicle valve concave except for small gently convex umbonal region. Posterior margins straight, except near umbo which in some specimens is slightly elevated and excentric; apical angle ranging from 100° to 170°. Hinge line shorter than greatest width, which occurs near midlength; lateral margins rounding posteriorly into interarea. Interarea moderately low, 4 mm high and 15 mm wide and inclines at angle of 125° to plane of commissure in figured specimen (pl. 2, fig. 21). Pseudodeltidium moderately narrow, occupying slightly less than one-seventh of interarea width, its sides diverging anterior margin at points midway between center and lateral extremities of interarea.

Sculpture of pedicle valve parvicostellate but approaching multicostellate in central part; costellae separated by subequal intercostal sulci centrally, and slightly wider ones toward auricular extremities; 18 to 26 costellae occur in space of 10 mm. Fine concentric growth lirae cross costellae.

Interior of pedicle valve having moderately short median septum terminating apically in tiny spon-

dyliiform structure. Sectioning shows structure formed by dental plates buried within callus at apex and anteriorly delimiting tiny open pocket a little more than 1 mm in diameter; dental plates evanesce rapidly and become dental ridges anteriorly, within 2 to 3 mm of apex.

Brachial valve moderately convex; greatest convexity posterior to middle of valve and decreasing anteriorly; anterior and lateral slopes moderately inclined and gently convex; some specimens have shallow median sulcus in posterior part lessening to mere medial flattening of valve anteriorly. Surface sculpture of brachial valve similar to that of pedicle valve.

Internal structures of brachial valve poorly known. Cardinal process about 2½ mm wide, arched, supported by short socket plates that extend slightly less than 5 mm anterolaterally from umbo of valve. Adductor muscle field divided by shallowly discontinuous median ridge.

Pedicle valves not complete enough to give dimensions. Figured brachial valve is 28 mm long, 34 mm wide and 8 mm deep.

*Discussion*.—This species differs from *Orthotetes kaskaskiensis bransonorum* n. subsp. in having multicostellate sculpture, a narrower pseudodeltidium, and a shorter, less developed spondylium in the pedicle valve. Direct comparison with material collected by the writer and by Easton (1962, p. 42, 43) from the Alaska Bench Limestone in the Big Snowy Range, Mont., and cited by Easton as *Orthotetes* (*Derbyia*) sp. indicates that this is the same as the Montana species. Easton (1962, pl. 5, fig. 5) also figured one of the Alaska Bench specimens as *Orthotetes* (*Orthotetes*) sp.

Orthotetids with a tiny spondylium within the apical region of the pedicle valve here in the past been referred by paleontologists either to *Orthotetes* or to *Derbyia*. Presumably this vestigial structure represents a transitional stage between the two genera. Having been among those who once argued for Easton's identification of this species as a *Derbyia*, I hope that the brief discussion in this report under the genus *Orthotetes* will explain to the reader why I now consider it more correctly referred to *Orthotetes*. Briefly, the short socket plates in the brachial valve, together with the tiny spondylium in the pedicle valve, place this species in *Orthotetes*.

A pedicle valve figured by Easton (1962, pl. 4, figs. 17, 30) from the Devils Pocket Formation appears to have no spondylium; that is, no dental plates or ridges are in contact with the median sep-



tum. Brachial valves from the same collection still retain relatively short socket plates. It is questionable whether these shells from the Devils Pocket Formation should be included with this species.

*Figured specimens.*—USNM 163731–163733.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 53 (19), 54 (4), Johnson County. Ranchester Limestone Member: collections ?84 (10), Lincoln County; 139 (2), 141 (6), Teton County.

*Orthotetes* sp.

Plate 2, figures 11, 18

An incomplete septate pedicle valve from the Moffat Trial Limestone Member is referred to *Orthotetes*. Concentric growth furrows and ridges indicate that the length of the valve is equal to about three-quarters its width, the lateral margins slightly recurved to meet the posterior margins at an angle of about 100°. Except for the elevated area around the umbo, the valve is flat, with irregularities. The interarea also is flat, inclined at an angle of 73° to the plane of the valve, 9 mm high, its length not known but estimated to be 45 to 50 mm. The delthyrium, partly covered by a pseudodeltidium, most of which has been broken away anteriorly, has an apical angle of approximately 30° and is 5 mm wide at the hinge line. A prominent, slightly elevated perideltidium is 23 mm wide (twice the half length) at the hinge line. The umbo is acute and slightly incurved.

The surface sculpture is parvicostellate, consisting of narrow, rather sharp costellae separated by much wider interspaces; eight to nine costellae occur in the space of 5 mm. These are crossed by fine concentric lirae, strongest and somewhat zigzag in the intercostal sulci. A medium septum is present.

This shell appears to be nearest to *Orthotetes kaskiensis bransonorum* n. subsp. but differs in having a higher interfarea, narrower delthyrium, more prominent perideltidium, and slightly wider, spaced costellae. Whether dental plates are developed or not is not known, but because the stratigraphic position of this shell is well below the lowest known occurrence of *Derbyia* in the west American section, it has been referred to *Orthotetes*.

*Figured specimen.*—USNM 163730.

*Occurrence and number of specimens.*—Moffat Trail Limestone Member: collection 93 (1), Lincoln County.

Genus DERBYIA Waagen, 1884

*Derbyia* cf. *D. robusta* (Hall)

Plate 2, figures 30, 31, 33–35, text figure 3G

*Orthis robusta* Hall, 1858, p. 713, 714, pl. 28, figs. 5a–d.

*Derbyia robusta* Hall. Hall and Clarke [part?], 1892, pl. 10, figs. 12–15 [not figs. 16, 17].

*Description.*—Pedicule valve shallowly convex to approximately flat, with convex umbonal region; outline transversely subelliptical; greatest width near middle of valve; hinge line somewhat shorter than greatest width; shell rather irregularly thickened concentrically near anterior and lateral margins, commonly with rather prominent concentric furrow a few millimeters from edge. Interarea moderately low, wide, and slightly concave in side profile, inclined at angle of 120° to plane of commissure. Umbo slightly protruding, shallowly incurved, and bluntly pointed. Pseudodeltidium narrow.

Strong external sculpture in pedicle valve consists of narrow elevated costellae separated by wider intercostal sulci; 8 to 10 (normally 9) costellae occur in space of 5 mm. Sculpture parvicostellate, having weaker costellae intercalated between two stronger ones. Radial sculpture crossed by low concentric threads giving minutely beaded appearance to points of junction with costellae. Shallow growth furrows and minute growth lirae also present. Pseudopunctae exposed on partly eroded shells.

Interior of pedicle valve marked in umbonal region by median septum on floor of valve that bisects somewhat flabellate muscle-scar field. Field rests on rudely subtriangular callus, about 20 mm long and 18 mm wide in one specimen (USNM 163738), bordered by slightly raised ridge. Dental thickenings or ridges flank delthyrium.

Brachial valve broad, tumid, strongly convex throughout, in side and anterior profiles; greatest convexity near umbo. Anterior part generally less thickened than in pedicle valve, but faint concentric furrows present in some specimens. Surface sculpture similar to that of pedicle valve, except that as many as five fine costallae intervene between two strong ones, with one or three costella more typical.

Interior of brachial valve with bilobate cardinal process extending outward at posterior margin, approximately at right angles to plane of commissure; chilidial plate strong, divided; cardinal process strongly arched anteriorly, extending anterolaterally in pair of socket plates of undetermined length; no anterior median ridge visible on underside of process.

*Dimensions (in mm).—*

|                           | <i>Pedicle valve</i> |                 | <i>Brachial valve</i> |
|---------------------------|----------------------|-----------------|-----------------------|
|                           | USNM<br>163734       | USNM<br>163737  | USNM<br>163735        |
| Length -----              | <sup>1</sup> 45      | 46.5            | 35                    |
| Maximum width -----       | 54                   | <sup>2</sup> 56 | 48                    |
| Thickness -----           | 10                   | 9               | 18                    |
| Height of interarea ----- | 8                    | 7               | —                     |
| Width of interarea -----  | 48                   | <sup>2</sup> 48 | —                     |

<sup>1</sup> Estimated (broken umbo).<sup>2</sup> Twice the half width.*Dimensions of Hall's holotype of D. robusta*<sup>1</sup> (in mm).—

|                           | <i>Pedicle valve</i> | <i>Brachial valve</i> |
|---------------------------|----------------------|-----------------------|
| Length -----              | 64.5                 | 58.5                  |
| Maximum width -----       | 76.5                 | 76.5                  |
| Thickness -----           | 13                   | 22                    |
| Height of interarea ----- | 11                   | —                     |
| Width of interarea -----  | 68                   | —                     |

<sup>1</sup> From the plastoholotype, USNM 62502.

*Discussion.*—The description above is based upon specimens from the Ranchester Limestone Member in the Rawlins hills, where this species seems to be fairly common. The Amsden specimens are closely related to *Derbyia robusta* (Hall), described originally from beds of probable Des Moinesian age (Dunbar and Condra, 1932, p. 113) in St. Clair County, Ill., and probably are conspecific with that species. They are somewhat smaller than Hall's holotype which, according to Dunbar and Condra (1932, p. 113), is lost. Plaster casts of it, however, are in the collections of the U.S. National Museum and the American Museum of Natural History. One of these (USNM 62502) has been compared directly with the Wyoming material; its measurements are given in the table above.

One moderate discrepancy between the Wyoming species and Hall's original description is the presence of a shallowly convex pedicle valve in Wyoming shells and of a flat pedicle valve, concave, in the middle, in Hall's type. On close examination the cast of the holotype shows a strongly convex umbonal region; including the interarea, the convexity amounts to 13 mm. Near the anterior margin of the valve the convexity amounts to 7 mm. In between, the central part of the valve is shallowly concave. Possibly this central depression in the valve was caused by crowding during growth or by slight compaction after burial.

Characteristic of Hall's species and of the Wyoming specimens are the following: the considerable convexity of the brachial valve, the wide interarea inclined at 120° to the plane of commissure, and the fairly coarse sculpture—eight to nine costellae in the space of 5 mm on the plastoholotype.

One unresolved difference remains. The only interarea exposed in a Wyoming specimen is gently concave in side profile, whereas that of Hall's specimen is approximately flat. This difference, the lack of sufficient topotype material of *D. robusta* to work out of its range of variation, and the lack of sufficient Wyoming specimens with palintropes suitable for grinding and sectioning are responsible for the Wyoming shells being merely compared with Hall's species.

In the Amsden Formation the presence of a median septum in the pedicle valve will distinguish this species from all davidsonaceans except those referred to *Orthotetes*, and the highly convex brachial valve will distinguish it from these, as well as the others.

*Derbyia robusta* has been cited in the literature at several localities, but most of these occurrences should be reviewed. The *Orthotetes robusta* (Hall) figured by Mather (1915, p. 146, pl. 9, figs. 2–3a) from the Morrowan Series of Arkansas, as well as the *Derbyia robusta* figured by Morningstar (1922, p. 177, pl. 8, fig. 11) from beds of Pottsville age in Ohio almost certainly do not belong in this species.

*Figured specimens.*—USNM 163734–163737.

*Mentioned specimen.*—USNM 163738.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 1 (3), 2 (1), 3 (6), 4 (4), ?5 (1), Carbon County. Ranchester Limestone Member: collections 6 (1), ?15 (3), Carbon County.

Suborder CHONETIDINA  
Superfamily CHONETACEA Bronn  
Family CHONETIDAE Bronn

Genus EOLISSOCHONETES Hoare, 1960

*Eolissochonetes* Hoare, 1960, p. 220; 1961, p. 37, 38; Muir-Wood, 1962, p. 75, 76; Muir-Wood, in Moore, 1965, p. H430.

*Description.*—Smooth subrectangular chonetids with or without broad low sulcus in pedicle valve. Cardinal extremities approximately right-angled, ranging from slightly rounded to slightly produced. Interior of pedicle valve having median septum paralleled anteriorly by two main vascular trunks near middle of valve and ornamented by closely scattered papillae. Brachial valve having pair of socket ridges meeting just behind alveolus to support sessile cardinal process; median septum moderately long and fairly high, extending forward from alveolus and apex of lateral septa, flanked by radial rows of papillae that in thick shells may be fused into radial ridges.

*Type species.*—*Chonetes laevis* Keyes, 1888 [not Davidson, 1866] by original designation, (= *Eolissochonetes keyesi* Muir-Wood, 1962).

*Discussion.*—Hoare (1960, 1961) stated his belief that *Eolissochonetes* was derived from *Mesolobus mesolobus decipiens* (Girty), a smooth *Mesolobus* having a very subdued median lobe in the sulcus and regarded by Sturgeon and Hoare (1968, p. 30) as the typical form of *M. mesolobus* (Norwood and Pratten). He based this suggestion on the supposed closer similarity of the interior of *Eolissochonetes* to that of *Mesolobus* than to that of *Chonetes*. This statement is difficult to evaluate at present because Hoare did not say which species of *Chonetes* he regarded as typical of the genus. The statement is certainly true of *Chonetes* as presently restricted to beds of Early Devonian to earliest Early Carboniferous age (Muir-Wood, 1962, p. 36; Muir-Wood, in Moore, 1965, p. H420). The Carboniferous species in North America formerly included in *Chonetes* are now referred variously to *Rugosochonetes*, *Neochonetes*, *Retichonetes* and other genera. One presumes that Hoare probably was referring to the common Pennsylvanian species *Chonetes granulifer* Owen and related species now placed in *Neochonetes*. The internal differences between the type species of *Eolissochonetes* and typical *Rugosochonetes* and *Neochonetes* do not seem to me to be greater than those between *E. keyesi* and typical *Mesolobus*.

It is difficult, moreover, to conceive of evolution rapid enough to account for the derivation of *E. keyesi* from *M. mesolobus decipiens* when the two species occur together in the same beds of Middle Pennsylvanian (Des Moinesian) age in southwest Missouri. One will have to go a little farther back, it would seem, to find the ancestors of *E. keyesi*. This species has, in fact, been identified by Mather (1915, p. 151) as "*Chonetes laevis* Keyes" from the type Morrowan of northwestern Arkansas, although whether it is the same as the shell from Des Moinesian Series is open to question. Also described by Mather (1915, p. 150) from beds he regarded as belonging in the Morrowan, but which M. K. Elias (oral commun., 1967) has determined as belonging in the overlying Atokan Series, was *Chonetes choateuensis* Mather, which probably was ancestral to *Mesolobus*.

Chonetids with smooth shells, having interiors that are similar both to *Eolissochonetes* and *Rugosochonetes* are rather common in late Chesterian and Morrowan equivalents in the western United States. They probably were derived from *Rugosochonetes* through some species such as *Chonetes sericius* Girty, of the Fayetteville Shale of Arkansas and Oklahoma, which bears fine capillae in the medial part of the shell and has the auricular extremities

virtually smooth. It is proposed here to refer the smooth Amsden chonetids to *Eolissochonetes* and to regard this genus as derived probably in Late Mississippian (Chesterian) time from species now included in *Rugosochonetes*.

*Eolissochonetes pseudoliratus* (Easton)

Plate 1, figures 42–50, 52

*Chonetes pseudoliratus* Easton, 1962, p. 44, 45, pl. 5, figs. 8–13.

*Diagnosis.*—Moderately small shell, gently concavo-convex; surface smooth, appearing lirate (capillate) where abraded. Interior of brachial valve having median septum fused posteriorly to pair of lateral septa.

*Description.*—Pedicule valve transverse suboval to semicircular in outline; posterior margins straight, diverging at apical angle of about 170°; greatest width approximately at midlength or, less commonly, at or near hinge. Surface evenly convex in side profile or having anterior part more convex than posterior part; anterior slope fairly flat or depressed into faint sulcus. Interarea low, inclined at angle ranging from 120°–140° to plane of commissure. Triangular delthyrium partly covered apically by gently convex pseudodeltidium. Surface smooth, sculptured only by sparse concentric grooves and lines of growth, but appearing capillate where abraded; 28 to 30 internal capillae occurring in space of 5 mm. Posterior margin ornamented by six or seven, rarely eight, spines of unknown length at either side of apex, diverging toward auricular extremities at angles approximating 60° to margin.

Interior of pedicle valve having short platelike septum, highest near beak, extending forward as faint low ridge, terminating a little beyond midlength. Pair of adductor muscle scars occupying smooth sloping thickened areas at either side of midseptum. Pair of low short ridges, or vascular trunks, flanking end of septum and extending a little beyond it at middle of valve. Diductor muscle scars occupying slightly depressed fan-shaped areas, one at either side of median septum and vascular trunks, beginning just in front of apex and extending not quite to midlength, faint to unrecognizable on young shells. Radial rows of papillae well developed within valve, particularly in band near anterior and lateral margins.

Brachial valve gently concave—either evenly so or almost flat posteriorly and moderately concave anteriorly. Surface sculpture like that of pedicle valve. Interarea inclined at angles ranging from 55°–75° to plane of commissure. Notothyrium closed

apically by crescent-shaped chilidium bordering quadrilobate cardinal process.

Interior of brachial valve with short cardinal process at posterior margin, supported by socket ridges that diverge at angle of  $135^\circ$ , tending to broaden and bifurcate shallowly as they die out; four ridges of myophore meeting apically. Round pit of myophore present immediately in front of cardinal process. Median septum low near alveolus, becoming higher anteriorly and extending about two-thirds of distance across valve, fused posteriorly with pair of lateral septa that diverge at angle of  $60^\circ$  to each other and extend almost one-third of distance across valve. Middle part of valve has two raised elongate areas that continue diagonally from lateral septa, broaden slightly and die out in medio-lateral part of valve; between these and socket ridges are two subtriangular depressions, and another pair of depressions occurs between these raised areas and median septum. Rather thick endospines are closely scattered along anterior part of valve.

*Dimensions (in mm).—*

|                 | USNM<br>163739   | USNM<br>163740 | USNM<br>163741 | USNM<br>163742 |
|-----------------|------------------|----------------|----------------|----------------|
| Length -----    | 10.5             | 9.5            | 8.5            | 8.2            |
| Width -----     | 14.5             | 15.6           | 10.5           | 12.5           |
| Thickness ----- | <sup>1</sup> 2.2 | 2.6            | 3.5            | 2.4            |

<sup>1</sup> Slightly crushed specimen. All specimens from collection 157.

*Discussion.*—The description above is based on our Wyoming shells. Measurements given in the table are for the four complete specimens figured on plate 1, which show some of the variations in shape found in this species. All are from the same locality on Berry Creek. The proportions of these shells are, in general, similar to those of Easton's specimens from the Cameron Creek Formation and Alaska Bench Limestone of central Montana (Easton, 1962), and they have about the same size range. Internal characters are similar, but those of Easton's figured specimens are a little more delicate and the endospines finer than in our figured Amsden shells. As the brachial valves figured by Easton are a little smaller than ours, these differences may be attributable largely to differences in growth stage.

*E. pseudoliratus* is similar in shape and sculpture to *E. ? suttoni* (C. Branson); they may in fact be conspecific. Easton (1962, p. 45) separated the two on the basis of the large size and presence of a broad sulcus in *E. ? suttoni* as opposed to the smaller size and absence of a sulcus in *E. pseudoliratus*. Our specimens of *E. pseudoliratus* are both with and without shallow sulci. As the internal characters of Branson's unique holotype are not known, whereas

the characters of Easton's species are based on many specimens, we have chosen to retain Easton's name for the common Amsden species. Branson's form is discussed separately.

Specimens from the Ranchester Limestone Member in western Wyoming are Early Pennsylvanian (Morrowan) in age. Specimens from the Horseshoe Shale Member at Berry Creek, Teton Range are shown by associated Foraminifera of Mamet's Zone 19 to be latest Mississippian (latest Chesterian) in age.

*Figured specimens.*—USNM 163739–163745.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 153 (6), 157 (115), Teton County. Ranchester Limestone Member: collections 67 (3), Sheridan County; ?97 (1), Lincoln County; 133 (90), Sublette County; 141 (5), 142 (28), Teton County.

*Eolissochonetes? suttoni* (C. Branson)

Plate 1, figures 35–39

*Chonetes suttoni* C. Branson, 1937, p. 656, pl. 89, figs. 8, 9.

The holotype of this species is the only specimen definitely assigned to it. It is large for the genus, measuring (in mm): length 13, width 20.5 (19.5 at midlength), and thickness 3.4. The shell is subrectangular in outline although more rounded anteriorly, concave-convex in longitudinal cross section. The pedicle valve is nearly flat posteriorly and becomes more convex toward the anterior margin. A shallow sulcus is present on the middle of the anterior slope. The auricular extremities are subangular, although one side has been rounded off by abrasion. The low interarea is inclined at  $125^\circ$  to the plane of commissure and is perforated medially by a triangular delthyrium partly covered apically by an indistinct pseudodeltidium.

The brachial valve, is like the pedicle valve, nearly flat posteriorly but concave overall, the concavity greatest near the middle. A faint shallow fold corresponds to the sulcus of the pedicle valve. The interarea is low and inclined at approximately  $70^\circ$  to the plane of commissure. Its apical area is somewhat worn so that one has difficulty in telling whether a single chilidium or a pair of chilidial plates are present. The myophore of the cardinal process is quadrilobate but appears trilobate owing to the close spacing of the two central ridges.

Both valves are smooth but have internal capillae, of which 28 to 30 occur in the space of 5 mm. Hinge spine bases are indistinct, but appear to be spaced about the same as on *E. pseudoliratus*. Because of

the wider shall there may have been as many as 10 of them.

The unique specimen to which Branson attached the name *Chonetes suttoni* came from an undisclosed locality and horizon along the Little Popo Agie River, Wind River Range. Except for its large size, it generally resembles specimens from Berry Creek here referred to *Eolissochonetes pseudoliratus* (Easton). Its internal characters, however, are unknown. An attempt was made to bring out some of these by passing reflected light through the specimen while it was immersed in water. Although a lighter colored area was detected extending forward from the beak of the pedicle valve in the position of the median septum and its thickened base, no indications whatsoever were noted in the brachial valve, suggesting that it must be fairly thick.

Because so much uncertainty exists as to the internal characters and even the provenance of this shell, it is regarded in this report as a species inquirenda.

*Type*.—Holotype, UM 6832.

*Occurrence*.—Horseshoe Shale Member(?): collection 36d, Fremont County.

Genus MESOLOBUS Dunbar and Condra, 1932

*Mesolobus* sp.

Plate 1, figures 31–34

*Description*.—Moderately small chonetid, having greatest width between hinge line and midlength. Pedicle valve moderately to shallowly convex; in side profile, curvature greatest near midlength but almost imperceptibly so; in posterior profile, valve is convex in umbonal region and middle of arch but sloping rather straight toward and becoming gently concave near lateral margins. Sulcus broad and shallow, beginning about 2 mm in front of beak, gradually widening at about 30° angle toward anterior margin. Bottom of sulcus occupied by low, gently rounded median lobe weakly delimited from rest of sulcus. Surface smooth, appearing lirate where eroded, marked concentrically and irregularly by faint growth lines. Posterior margin having probably as many as seven spines on each side of beak.

Brachial valve exterior not exposed. Interior of brachial valve having rather strong median septum, elevated anteriorly, bisecting raised platform. Other details poorly preserved.

*Dimensions (in mm)*.—

|                 | USNM<br>1 163746 | USNM<br>1 163747 | USNM<br>2 163748 |
|-----------------|------------------|------------------|------------------|
| Length -----    | 9.7              | 7.9              | 7.5              |
| Width -----     | 12.9             | 13.5             | 11.0             |
| Thickness ----- | 3.0              | 3.9              | 2.6              |

<sup>1</sup> USNM 163746 and 163747 are from collection 15.

<sup>2</sup> USNM 163748 is from collection 6.

*Discussion*.—Eroded specimens show what appear to be capillae, particularly over the antero-medial part of the shell; toward the cardinal extremities, scattered tiny pits show through the shell or are exposed by weathering. Also, some subcircular clusters of what resemble lirae, actually beekite (silicification) rings, are developed locally where the shell is partly silicified. All these are secondary phenomena or are exposed by secondary phenomena and do not alter the fact that the shell surface in reality was smooth.

The shallow sulcus, weak median lobe, and smooth surface of these shells suggest that they are closest to weakly sulcate forms of *Mesolobus mesolobus* (Norwood and Pratten), as the type species of *Mesolobus* is interpreted by Sturgeon and Hoare (1968, p. 31, pl. 6, figs. 1–24). *M. mesolobus* is common in rocks of Des Moinesian age in the American midcontinent. Our specimens from rocks of Atokan age in the northern Rocky Mountain region are not well enough preserved to permit detailed comparisons with *M. mesolobus*. The consistently shallow sulcus and obsolete median lobe in the Wyoming specimens, as well as the difference in age, suggests that they may actually represent a closely related but distinct species. Other similar species that include specimens having an obsolete sulcus and median lobe are *M. striatus* Weller and McGhee and *M. obsoletus* Sturgeon and Hoare. Both of these species differ from the Wyoming form in having longitudinal lirae ornamenting the surface of the shell.

*Figured specimens*.—USNM 163746, 163747.

*Measured specimen*.—USNM 163748.

*Occurrence and number of specimens*.—Ranchester Limestone Member, collections 6 (2), 15 (4), Carbon County.

Suborder PRODUCTIDINA  
Superfamily PRODUCTACEA Gray  
Family OVERTONIIDAE Muir-Wood and Cooper  
Genus SCOLOCONCHA Gordon, 1966

*Scoloconcha globosa* (Mather)

Plate 3, figures 20–22

*Pustula globosa* Mather, 1915, p. 167, 168, pl. 10, figs. 7–9.

*Horridonia globosa* (Mather). Plummer, 1950, pl. 11, fig. 2.

*Scoloconcha globosa* (Mather). Gordon, 1966, p. 584.

Two small spinose productoids, in a collection from the Rawlins hills, are referred to Mather's species. The identifying characters of this species are the subhemispherical shape, incurved beak, and almost smooth surface bearing faint concentric growth lines and sparsely scattered spine bases. Dimensions of the more complete specimen (in mm) are: length 9.5, greatest width 9 (twice the half

width), and depth 5.5 mm. The hinge appears to be shorter than the greatest width, but the aural extremities are broken off so one cannot be sure. Comparison of the Wyoming shells with specimens of *S. globosa* from the Brentwood Limestone Member of the Bloyd Shale in the type region of the Morrowan Series in Washington County, Ark., indicates that they are conspecific.

*S. indianensis* (Hall), the type species of *Scolaconcha* and only other described species thus far referred to the genus, can be distinguished from *S. globosa* by the elongate oval outline of its pedicle valve, shorter trail, less incurved beak, more spines, and slightly smaller size.

Foraminifera of Mamet's Zone 20 from this same Amsden collection independently confirm its Morrowan age. This species is now known from Arkansas, Oklahoma, Texas, and Wyoming.

*Figured specimen*.—USNM 163790.

*Occurrence and number of specimens*.—Ranchester Limestone Member: collection 13 (2), Carbon County.

Family MARGINIFERIDAE Stehli  
Genus INFLATIA Muir-Wood and Cooper, 1960

*Inflatia lovei* n. sp.

Plate 3, figures 1-9

*Dietyoclostus portlockianus* (Norwood and Pratten). Burk, 1954, p. 9, pl. 1, figs. 29, 30.

*Diagnosis*.—Small to moderate-sized *Inflatia* with or without shallow median sulcus in pedicle valve; ornamented by 12 to 14 costae in space of 10 mm on anterior slope and with scattered erect coarse spines near anterior margin.

*Description*.—Shall elongate, subrectangular in outline, rounded posteriorly; widest just in front of hinge. Pedicle valve rather deep, convex; greatest curvature at umbo and decreasing gradually toward anterior margin; lateral slopes steep; ears not strongly differentiated; commonly without median sulcus, but where present sulcus is narrow, fairly shallow, beginning about 5 mm in front of beak and continuing on to anterior slope where, in some specimens, it dies out. Beak protruding a millimeter or two beyond hinge line.

Sculpture on pedicle valve of low rounded costae separated by narrow intercostal grooves; six or seven costae occurring in space of 5 mm on anterior slope; some scattered costae more elevated than others, these generally bearing spines; costae increasing by bifurcation, very rarely by intercalation. Several concentric furrows present in posterior part, including umbonal region. Spines erect, as much as

1.4 mm in diameter on anterior slope and 2 mm in diameter on flanks occurring (1) on coarser costae, 1.5 to 6.5 mm apart on a single costa and totaling about 25 in all near anterior margin, (2) two to three on flank just anterior to ear, and (3) in row of four or five along hinge at either side of umbo.

Interior of pedicle valve with raised adductor muscle-scar platform beginning approximately 5 mm anterior to beak, roughly 10 mm long, 5 mm wide near posterior end, tapering to 3 mm near anterior end, as much as 3 mm high; entire adductor muscle-scar field appears dendritic. Diductor muscle scars in two fan-shaped areas at either side of adductor muscle-scar platform, each radially grooved and approximately 8 mm wide at anterior end. Area within ears smooth. Small endospines closely spaced over anterior part of visceral disc and within trail.

Brachial valve concave, of moderate depth; ears fairly well differentiated from visceral disc by shallow folds; anterior edge of visceral disc rounding into trail or rather abruptly geniculate on some specimens; trail continuing at angle that ranges from 65° to 80° to floor of valve. Gentle median fold present on some shells, corresponding to sulcus of pedicle valve. Valve ornamented by costae as in pedicle valve; a few weak rugae present over visceral disc, particularly near sides. Spines not observed and presumably absent.

Interior of brachial valve having convex visceral disc produced into fairly short trail; cardinal ridges narrow, short, tilted posteriorly, and apparent only in immediate vicinity of posterior platform, merging with floor of valve about 3 mm laterally from cardinal process. Cardinal process short, sessile; myophore bilobate above and trilobate posteriorly. Posterior platform moderately broad, merging anteriorly with shallow end of pair of subtriangular adductor muscle-scar platforms; brevisseptum emerging from between anterior raised edges of adductor muscle-scar platforms, higher and narrowing to knife edge anteriorly, extending forward to point about three-fifths of way across visceral disc. Each muscle-scar platform bearing dendritic posterior adductor muscle scar and, anterior to it, small area where anterior adductor muscle presumably attached. Brachial ridges take off near anterior ends of muscle-scar platforms, curving anteriorly, enclosing raised oval areas about 5 mm long and 3 mm wide. Interior of trail radially liriate; lirae bearing scattered short, anteriorly directed endospines, particularly in anterolateral areas.

*Dimensions (in mm).—*

|                         | <i>Pedicle valves</i> |                 | <i>Brachial valves</i> |                 |
|-------------------------|-----------------------|-----------------|------------------------|-----------------|
|                         | USNM<br>163749        | USNM<br>163750  | USNM<br>163751         | USNM<br>163752a |
| Length -----            | 28                    | 26              | 23                     | <sup>1</sup> 18 |
| Length along arch ----- | 52                    | 48              | 26                     | <sup>1</sup> 22 |
| Maximum width -----     | <sup>2</sup> 28       | <sup>3</sup> 25 | 29                     | 27              |
| Width of hinge -----    | 24                    | 23              | <sup>2</sup> 26        | 25              |
| Depth -----             | 16                    | 16              | 9                      | <sup>1</sup> 5  |

<sup>1</sup> Lacking small part of trail. All specimens from collection 47.

<sup>2</sup> Estimated.

<sup>3</sup> Twice the half width.

*Discussion.*—This description is based principally on specimens from the Horseshoe Shale Member at Wiggins Fork (colln. 47), from which have been selected the holotype and nine paratypes. The calcareous shells at that locality are preserved somewhat imperfectly in fine sandstone, but all their salient characters can be seen. Also studied were 14 specimens from Wiggins Fork in the collection of Yale University's Peabody Museum. Three of these have been designated as paratypes. Considerable variation in curvature is present in these specimens, the side profile of some pedicle valves showing fairly marked geniculation over the posterior part of the visceral disc.

Specimens of *I. lovei* from Horse Creek in the collection of the University of Wyoming (colln. 43) have considerable variation in the depth of the sulcus, some lacking one altogether. The specimen having the deepest sulcus in this lot was figured by Burk (1954, pl. 1, figs. 29, 30) as *Dictyoelostus portlockianus* (Norwood and Pratten). Presence of some relatively large spine base scars that interrupt costae on the anterior slope of the pedicle valve in both sulcate and nonsulcate forms indicates that they represent only one species, and the differences in sulcation are due to individual variation.

*Inflatia inflata* (McChesney differs from *I. lovei* in having a wider shell with a larger area of posterior slope and a much larger and deeper sulcus in the pedicle valve, more regular and fewer costae, and more steeply inclined trail in the brachial valve. The same characters differentiate *I. bilobata* Sadlick from this species, except that the spines in the Utah species approach in size those of *I. lovei*.

*I. spinolinearis* (Easton) differs from *I. lovei* in being broader across the vault of the shell, having steeper flanks marked by a row of spines, the spines smaller, and a deeper brachial valve. *I. obsoleta* (Easton) differs from *I. lovei* in having a fairly smooth anterior slope, smaller spines, a more deeply concave brachial valve, and a wider adductor muscle-scar platform in the pedicle valve. *I. confluens* (Easton) is differentiated by its smaller size, subparallel steep flanks, fairly prominent rounded sulcus, and

confluent costae in the middle of the anterior slope.

*Types.*—Holotype, USNM 163749; paratypes, 163750–163753, 163791, YPM 20104a, g, h.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 21 (1), 43 (8), 44 (5), 45 (27), 47 (40), 48 (14), Fremont County; 41 (7), Teton County. Ranchester Limestone Member: collection ?82 (6), Lincoln County.

## Genus RUGOCLOSTUS Easton, 1962

*Rugoclostus* Easton, 1962, p. 59, 60.

*Description.*—Medium-sized to moderately large productoids resembling semireticulate group in shape. Umbo smooth or ornamented only by concentric wrinkles. Costae and costellae beginning in front of umbo and either extending to anterior margin or becoming obsolete or dying out entirely on anterior slope; rugae prominent in posterior part. Moderately coarse long spines scattered on both valves, except on umbones, commonly having a cluster on ears of brachial valve. Pedicle valve hinge having well-developed ginglymus. Pedicle interior having elongate oval dendritic adductor muscle scars on broad low elongate platform between pair of large diductor muscle scars.

Brachial valve with large, fairly short, wide cardinal process having trilobate myophore, attached by short neck to posterior platform from which extend strong cardinal ridges. Adductor muscle scars set on thickened subtriangular platforms near posterior end of valve at either side of median septum; brachial ridges prominent, enclosing raised thickened areas. Anterior part of visceral disc and trail studded with thick, fairly long and sharp endospines.

*Type species.*—*Rugoclostus nivalis* Easton 1962, by original designation.

*Discussion.*—This genus is recognized by its shape, somewhat like *Inflatia*, but is generally larger and has more prominent ears. Some of the smaller forms are very much like *Inflatia* but can be distinguished by their having spines on the brachial valve. The long posterior slope and prominent umbonal region in *Rugoclostus* also helps to distinguish this genus from *Inflatia*. The obsolete sculpture in the anterior part of some species of *Rugoclostus* is distinctive. The ginglymus present along the hinge in the pedicle valve, which was interpreted by Easton in the type species as a true interarea, is also a characteristic feature.

At present only three species assignable to this genus are known. Besides the type species these



include *Productus semistriatus* Meek, 1860, and *Rugoclostus williamsi* n. sp. In addition to these, some undescribed species occur throughout the West. At least five species are present in the Great Basin. This genus is of particular interest because it seems to be restricted to western rocks of Morrowan age. It is not known, however, in the type region of the Morrowan Series in northwestern Arkansas.

*Rugoclostus williamsi* n. sp.

Plate 3, figures 10-18

*Diagnosis.*—Moderate-sized *Rugoclostus* having well-developed costae on both valves that begin near umbo and continue to anterior margin; 10 to 12 of these occur in space of 1 cm on middle of anterior slope. Coarse spines sparsely distributed on pedicle valve; fine spines fairly common on brachial valve.

*Description.*—Pedicel valve subhexagonal in outline, having wide hinge but even wider lateral margins so that greatest width is approximately two-thirds of way from posterior to anterior margin. In side profile greatest convexity is at or near umbo, but convexity decreases a little unevenly posterior slope with areas of greater convexity giving faint geniculate appearance at points roughly 15 and 25 mm, respectively, along arch from umbo; trail gently convex. Posterior profile having deep, almost V-shaped median sulcus flanked by well-rounded summits; flanks steep, becoming straight anteriorly. Median sulcus beginning as flat shallow depression 8 mm in front of umbo and continuing to anterior margin, having steeply sloping sides and narrowly rounded bottom on anterior slope. Posterior slope of umbonal region elongate; umbonal slopes steep, rounding rapidly into ears, diverging anteriorly at angle of 85°. Ears prominent, moderately long, highly arched, each set off by diagonal sulcus. Beak protruding about 2 mm beyond hinge line.

Ornamentation of pedicle valve consists of costae, concentric wrinkles, and spines. Umbo smooth; costae beginning 5 or 6 mm in front of umbo intercostal grooves of approximately same width as costae; costae increasing by bifurcation and tending to become fasciculate on flanks near anterior margin; six or seven costae occur in space of 5 mm over posterior part of visceral disc where concentric wrinkles terminate, and five or six occur in same space on anterior slope. Concentric wrinkles weak, indistinct, limited to posterior one-third of valve, beginning about 5 mm in front of umbo, strongest on umbonal slopes; faint growth lirae also present. Spines are of two main types: (1) a row of fairly

fine spine bases along hinge, directed posterolaterally; and (2) coarse suberect spines, as much as 1 mm in diameter at base, scattered sparsely over shell; paratype (pl. 3, figs. 13, 14) has one of largest spines on ear near base of umbonal slope and another farther out on ear.

Pedicel valve interior having raising adductor muscle-scar platform of arborescent appearance, 1 cm long, rising gradually in umbonal region, 7 mm in front of umbo, nearly 7 mm wide at posterior end, and narrowing to 5 mm near anterior end; surface of platform fluted posteriorly by low rounded ridges that tend to coalesce anteriorly, nearly smooth near anterior end where two small depressions to which anterior pair of adductor muscles probably were attached indent platform near its sloping anterior end. Diductor muscle scars longitudinally ridged, occupying rounded subtriangular depressions at either side of muscle scar platform, each 5 mm long by 7 mm wide. Anterior part of valve more coarsely ridged longitudinally, studded with small endospines.

Brachial valve gently concave over visceral disc, rounded strongly along anterior edge of disc into nearly straight, moderately long trail, having broad shallow fold that corresponds to sulcus of pedicle valve. Ornamentation consists of costae like those on pedicle valve crossed, particularly over visceral disc by few weak concentric wrinkles and grooves. Small spines present on trail, emanating from costae, tending toward alinement in concentric rows, increasing abundance toward anterior margin.

Interior of brachial valve poorly known. Cardinal ridges gently curved, fairly low, broadening slightly toward ears and dying out. Interior of trail studded with small prostrate endospines.

*Dimensions (in mm).—*

|                         | <i>Pedicel valves</i> |                   | <i>Brachial valve</i> |
|-------------------------|-----------------------|-------------------|-----------------------|
|                         | USNM<br>163754        | USNM<br>163755    | USNM<br>163757        |
| Length .....            | 29.5                  | <sup>1</sup> 29   | 25                    |
| Length along arch ..... | 60                    | 53                | 31                    |
| Maximum width .....     | <sup>2</sup> 32       | <sup>1 2</sup> 45 | <sup>2</sup> 35       |
| Width of hinge .....    | <sup>2</sup> 26       | <sup>2</sup> 41   | ?                     |
| Depth .....             | 21                    | <sup>1</sup> 16   | 11                    |

<sup>1</sup> Slight distortion by depression.

<sup>2</sup> Twice the half width.

*Discussion.*—The description above is based upon material from collection 100, the best of which have been illustrated on plate 3. All specimens assigned to this species without question are from the Covey Cutoff section. They were collected by our colleague, the late James Steele Williams, for whom this species is named.



A lot from the Ranchester Limestone Member in the Moffat Trail section (USNM 167719 from colln. 83), preserved as molds in chert, is identified as *Rugoclostus* cf. *R. williamsi*; one of them is figured (pl. 3, fig. 17). Valves are smaller than in the typical form, reaching widths of 22–27 mm. The costae over the visceral disc are moderately strong, and the same number occur in the space of 5 mm as in the typical form, but on the trail the costae become obsolete and tend to converge toward the sulcus as in "*Dictyoclostus*" *confluens* Easton.

Comparison of Easton's types of "*D.*" *confluens* with the Moffat Trail specimens shows that, although similar in appearance, they probably are not congeneric. "*D.*" *confluens* has no spines on the brachial valve and therefore belong in *Inflatia*. It has sharper costae than the Moffat Trail form. Brachial valves from the Moffat Trail lot all show spines present. One has a poorly preserved but typical brachial interior, preserving beneath a secondary growth of tiny quartz crystals the remains of the median septum, one of the subtriangular adductor muscle-scar platforms, and one of the brachial ridges, as well as some moderately sparse endospines on the edge of the visceral disc and on the trail. Possibly these specimens represent a species of *Rugoclostus* distinct from *R. williamsi*, but in the absence of sufficient material to demonstrate the range of variation in *R. williamsi*, the Moffat Trail lot is regarded as only a local variant. Examination of hundreds of specimens of *Rugoclostus* from the eastern part of the Great Basin in Utah has shown that individual populations in this genus show a considerable range in shell ornamentation.

*R. williamsi* looks very much like *Inflatia inflata* (McChesney), the species exceedingly abundant in the Chesterian rocks of the American midcontinent. The Late Mississippian species, however, differs in having more subdued, gently rounded costae, a shallower, slightly narrower sulcus, greatest width at or near the hinge and no spines on the brachial valve.

From *Rugoclostus nivalis* Easton our Wyoming species differs in having stronger costae, none of which disappear entirely on the trail, and more sparsely distributed coarser spines. *Rugoclostus semistriatus* (Meek), described originally from a locality near Provo, Utah, is a slightly smaller species having only a faint suggestion of a sulcus. Over the visceral disc about nine costae and costellae occur in the space of 5 mm; all of them become obsolete and disappear on the trail.

*Types*.—Holotype, USNM 163754; paratypes, USNM 163755–163757.

*Figured specimen*.—USNM 167719.

*Occurrence and number of specimens*.—Ranchester Limestone Member, USGS collections 83 [cf.] (4), 94 (2), 99 (1), 100 (11), Lincoln County.

Family PRODUCTIDAE Gray  
Genus DIAPHRAGMUS Girty, 1910  
*Diaphragmus cestriensis* (Worthen)

Plate 4, figures 1–4, 15–20, 22

*Productus elegans* Norwood and Pratten, 1854, p. 13, pl. 1, figs. 7a–c [not *P. elegans* McCoy, 1844]; Sutton, 1938 [part], p. 559, pl. 64, fig. 12 [not figs. 9–11].

*Productus cestriensis* Worthen, 1860, p. 570 [new name for *P. elegans* Norwood and Pratten, not McCoy]; Keyes, 1895, p. 44; Easton, 1942 [part], pl. 4, figs. 8, 9 [not fig. 10].

*Diaphragmus elegans* (Norwood and Pratten). Girty, 1910, p. 217; Weller, 1914 [part], p. 136–138, pl. 12, figs. 13–17 [not figs. 8–12]; Snider, 1915 [part], p. 84; Girty, 1915b, p. 59, pl. 3, figs. 5, 5a; Ulrich, 1917, p. 252, pl. 4, figs. 32–40; Butts, 1926 [part], p. 198, pl. 65, figs. 6, 7 [not figs. 8, 9]; Haas, 1946, p. 5; Elias, 1957, p. 505–509, text figs. 7–9.

*Diaphragmus (Productus) elegans* (Norwood and Pratten). Butts, 1917, p. 80, pl. 21, figs. 30–33.

*Diaphragmus motesanae* [sic] Ulrich, 1917, p. 252, pl. 4, figs. 25–31 [not figs. 1–24].

*Diaphragmus cestriensis* (Worthen). Croneis, 1930 [part], p. 74, pl. 19, figs. 20, 21 [not p. 54, pl. 13, fig. 10]; ?Cooper, in Shimer and Shrock, 1944 [part], p. 349, pl. 135, figs. 42, 43 [not figs. 44, 45]; Muir-Wood and Cooper, 1960 [part], p. 242, pl. 73, fig. 18 [not figs. 1–17].

*Diagnosis*.—Relatively small *Diaphragmus* having narrow pedicle valve and trail of moderate length, ornamented principally by 30 to 36 costae and costellae and numerous scattered spines, including spine patch on flanks near ears. Initial part of visceral disc in brachial valve subcircular.

*Discussion*.—Girty (1910, p. 217, 218) designated *Productus elegans* Norwood and Pratten as the type species of his new genus *Diaphragmus* and called attention to Worthen's substitution of the name *cestriensis* for Norwood and Pratten's name. Elias (1957, p. 505) regarded *Productus fasciculatus* McChesney as the type species because he believed the specimens that Girty actually had in hand when he described the genus *Diaphragmus* belonged in McChesney's species. Such an interpretation is not, however, compatible with Article 68 (a) of the International Code of Zoological Nomenclature (Internat. Comm. Zool. Nomenclature, 1961).

*D. elegans* and *D. cestriensis* have long been used as catch-all names for members of the genus *Diaphragmus*. Some authors have regarded *D. fasciculatus* as a synonym of *D. cestriensis*. As used in this

paper, the name *D. cestriensis* is applied rigidly to the rather small diaphragm-bearing productid species originally described as *Productus elegans* by Norwod and Pratten. This species is characterized by the nearly circular visceral disc in the brachial valve, the absence of a sulcus in the pedicle valve and in having 35 or less costae and costellae, the smallest number in any *Diaphragmus* now recognized.

Specimens from the Moffat Trail Limestone Member in Hoback Canyon are almost identical in all respects with specimens from Chesterian rocks in the Illinois basin. The Wyoming shells are strongly convex, particularly in the posterior part; on some the umbonal region is rather elongate. Two typical pedicle valves are illustrated (pl. 4, figs. 1-4, 15-18), also a poorly preserved brachial-valve interior showing relatively large adductor muscle-scar platforms (pl. 4, fig. 19), and a partly decorticated brachial valve showing the diaphragm area (pl. 4, figs. 20, 22). Costae and costellae number 30 to 35 on these specimens and average 33. Spines ornament all costae, are spaced 2 to 4 mm apart on individual costae, and occur as close together as 1 mm apart on adjacent costae. Spine patches on the flanks of these shells generally contain as many as 30 spine bases. Dimensions of three pedicle valves and one brachial valve are as follows.

*Dimensions (in mm).—*

|                   | Pedicle valves |                |                 | Brachial valve    |
|-------------------|----------------|----------------|-----------------|-------------------|
|                   | USNM<br>163764 | USNM<br>163766 | USNM<br>163767  | USNM<br>163765    |
| Length -----      | 18.8           | 15             | 14              | 12                |
| Length along arch | 34             | 27             | 28              | <sup>1</sup> 14.5 |
| Maximum width -   | 15             | 13             | 14.5            | 13                |
| Width of hinge -- | 12.5           | 11.2           | <sup>2</sup> 11 | 11                |
| Depth -----       | 11             | 10.2           | 10              | 3                 |

<sup>1</sup> Trail not complete. The trail of the first specimen is about 8 mm long.

<sup>2</sup> Twice the half width.

Another lot, from Covey Cutoff (colln. 93), differs slightly from the Hoback Canyon specimens in the presence of small rugae on the lateral slopes in the posterior part of the shell. These specimens are regarded as local variants of *D. cestriensis*.

This species is widely distributed in the Chesterian rocks of the American midcontinent. It is present in the Paint Creek Formation and ranges upward through the Menard and higher Chesterian formations of Illinois and Kentucky. In Arkansas this species is absent in the Batesville Sandstone and also seems to be missing in the Fayetteville Shale, but it is relatively common in the Pitkin Limestone. Its presence in the Moffat Trail Limestone Member of the Amsden Formation is in beds

that are in general equivalent to the Pitkin Limestone. Such a distribution suggests that in late Chesterian time this species broke out of the Illinois basin and became widely distributed in regions to the southwest and west. Typical *D. cestriensis* is, however, not known in the Great Basin region of Utah and Nevada.

*Figured and measured specimens.*—USNM 163710, 163764-163767.

*Occurrence and number of specimens.*—Moffat Trail Limestone Member: collections 93 (35±), Lincoln County; 120 (1), 121 (14), 122 (31), Teton County.

*Diaphragmus nivosus* n. sp.

Plate 4, figures 5-14

*Productus fasciculatus* McChesney. Easton, 1962, p. 48, 49, pl. 6, figs. 1a-5b.

*Diagnosis.*—Broad low shallowly sulcate *Diaphragmus* having wide hinge and moderately short trail. Ornamentation of 40 to 75 costae and costellae on both valves; rather coarse spines sparsely scattered on pedicle valve, including concentration of as many as 12 spines on each flank near ears.

*Description.*—Pedicle valve small to moderate-sized, subcircular to subtrapezoidal in plan; greatest width at or near hinge. Side profile with greatest curvature near umbo, decreasing anteriorly, but rather strongly convex just posterior to middle of visceral disc, giving faint geniculate aspect; anterior slope straight or nearly so. Posterior profile showing shallow sulcus over middle of valve, bounded by convex summits that round into nearly straight steeply inclined flanks; sulcus beginning within 1 cm of umbo, normally continuing and broadening somewhat to anterior margin, but on some specimens dying out on anterior slope. Umbonal flanks diverging at angles of 90° to 95°, but sloping off toward and merging with slightly arched ears; cardinal extremities forming acute angle. Umbo protruding slightly across hinge with little incurving.

Ornamentation of pedicle valve consisting of low, broadly rounded costae and costellae, separated by slightly narrower rounded intercostal grooves; six to nine occurring in space of 5 mm on anterior slope. Costae and costellae increasing by bifurcation, with some irregularity and tending toward fasciculation; some costae coalesce anteriorly, particularly in front of large spine bases. Concentric sculpture consisting of weak rugae on posterior part of valve, largely confined to umbonal slopes and flanks, weaker to absent over middle of vault; fine concentric growth lirae also present. Spines occur (1) in single row

along hinge at either side of umbo, generally directed posterolaterally; (2) scattered rather sparsely over surface of shell, emanating from costae, spaced 6 to 8 mm apart on anterior slope; and (3) in meager concentration of as many as 12 spines on flanks near ears.

Interior of pedicle valve having adductor muscle-scar platform consisting of low subparallel ridges, bisected by narrow median groove; platform is approximately 1 cm long and 3 mm wide, widest in anterior part, terminating roughly 15 mm in front of umbo. Diductor muscle scars at either side of platform longitudinally grooved and fluted, beginning about 8 mm in front of umbo, occupying subtrapezoidal areas approximately 6 mm long and a maximum of 5 mm wide, not strongly differentiated from costation of shell. Endospines short, sharp, and closely spaced within anterior part of visceral disc and trail.

Brachial valve geniculate, almost flat over visceral disc, bent sharply at intervals within diaphragm area to form several trails; innermost trail approximately straight, strongly inclined; outermost nearly at right angles to visceral disc, of moderate length (6–10 mm long in adult shells). Umbonal region slightly depressed along flexures that diverge from apex at 70°; gentle indistinct fold usually present on anterior part of visceral disc and on outer trails. Ears sloping more steeply than visceral disc and set off from it and from flanks of innermost trail by short diagonal ridge. Visceral disc wider than long; width of diaphragm area ranging from one-fourth to two-fifths length of visceral disc.

Costation on brachial valve similar to that of pedicle valve but without tendency toward fasciculation. Rugae indistinct, confined to lateral parts of visceral disc. Spines rare but scattered spine bases occur on innermost trail, spaced 3 mm and farther apart, also on ears.

Interior of brachial valve having short stout cardinal process, bilobate above and trilobate posteriorly. Small pit or alveolus present in some specimens or faint elongate depression where shaft meets posterior platform. Cardinal ridges straight, dying out laterally just short of diaphragm area. Adductor muscle-scar platforms subtriangular, thick; posterior part bearing dendritic posterior pair of muscle-scar impressions, slopes backward gently; anterior part extends forward in two smooth tapering lobes to which anterior pair of adductor muscles attached. Medium septum either passes weakly between adductor muscle-scar platforms or emerges as brevisseptum from between their anterior lobes; in front of plat-

forms, septum is bladelike, reaches height of 2.1 mm, and extends across smooth diaphragm area to anterior edge of visceral disc. Brachial ridges faint; prostrate endospines present on anterior part of visceral disc, also within trail.

*Dimensions (in mm).—*

|                     | <i>Pedicle valves</i> |                 |                 | <i>Brachial valve</i> |
|---------------------|-----------------------|-----------------|-----------------|-----------------------|
|                     | USNM<br>163758        | USNM<br>118763A | USNM<br>118764  | USNM<br>163759        |
| Length -----        | 23                    | 24.5            | 21              | 20.5                  |
| Length along arch - | 39                    | 42              | 36              | 24                    |
| Maximum width --    | <sup>1</sup> 27       | <sup>1</sup> 25 | <sup>1</sup> 24 | <sup>1</sup> 26       |
| Depth -----         | 13                    | 13.5            | 12.5            | 6.5                   |

<sup>1</sup> Twice the half width.

*Discussion.*—This species is based upon Easton's specimens of "*Productus fasciculatus*" from the Heath Formation in the Big Snowy Mountains of central Montana. The holotype (USNM 163758) is a shell that Easton did not figure; his figured specimens are regarded as paratypes, as are six additional specimens from the type locality (USGS colln. 13425-PC).

External characters and those of the interior of the pedicle valve in the description above are based on material from the type locality. Internal characters of the brachial valve are derived principally from specimens figured by Easton (USNM 118761, 118762) from two other localities. The holotype and a paratype, a brachial valve from the type locality, are figured on plate 4, figures 5–7, 12–14.

Specimens of *D. nivosus* from a locality in the Horseshoe Shale Member in western Wyoming are figured on plate 4, figures 8–11. The Wyoming specimens have the broad shell, shallow sulcus, low convex costae and costellae with narrow intercostal grooves, sparsely scattered spines, and transverse visceral disc that characterize the Montana species and are clearly conspecific with it.

*Diaphragmus nivosus* is closest in shape and costation to *D. fasciculatus* McChesney, which has a moderately broad shell indented by a shallow median sulcus in the pedicle valve, a transverse visceral disc in the brachial valve, and a similar range of the total number of costae and costellae on both valves. *D. nivosus* differs, however, in having a lower shorter shell bearing far fewer spines. On typical *D. fasciculatus* from the Mississippi Valley, more than 200 spines may occur on the pedicle valve, including patches of 35 to 40 spines on each flank. On *D. nivosus*, the two spine patches will not add up to as much as 30 spines, and the total number on the pedicle valve rarely, if ever, reaches 70.

*D. nivosus* differs from *D. cestriensis* (Worthen) in having a broader shell, a median sulcus in the

pedicle valve, transversely oval to subrectangular visceral disc in the brachial valve, and greater number of costae and costellae and notably fewer spines on both valves.

In its character of having relatively few fairly coarse spines scattered over the surface of the shell, *D. nivosus* also resembles *Carlinia diabolica* Gordon, a productid common in the latest Late Mississippian of Utah and Nevada. *D. nivosus* is, however, a true *Diaphragmus*, which differs from *Carlinia* in possessing well-developed trails in the brachial valve in place of numerous frills, spines on the brachial valve, a clearly differentiated diaphragm area on the interior of the brachial valve, and a spine patch on each flank of the pedicle valve.

*Types*.—Holotype, USNM 163758. Paratypes: USNM 118761; 118762; 118763A–C; 118764A, B; 163770 (totaling 13 specimens).

*Figured specimens*.—USNM 163758, 163759, 163768, 163769.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collection 41 (8), Teton County, Wyo. Primary types are from the Heath Formation, USGS collections 13409–PC (1 paratype), Fergus County; 13414–PC (3 paratypes), 14325–PC (holotype and 9 paratypes), Golden Valley County, Mont. See Easton (1962) for locality data.

**Genus CARLINIA Gordon, 1971**

*Carlinia amsdeniana* Gordon

Plate 4, figures 21, 23–37

*Diaphragmus phillipsi* (Norwood and Pratten) Branson and Greger, 1918, p. 314, pl. 19, figs. 5, 6.

*Pustula genevieveensis* (Weller). Branson and Greger, 1918, pl. 19, fig. 2 [not p. 315, 316, pl. 19, fig. 1].

*Marginifera muricatina* Dunbar and Condra. Burk, 1954, p. 10, 11, pl. 1, figs. 26–28.

*Carlinia amsdeniana* Gordon, 1971, p. 261, 262, pl. 1, figs. 9–13, 22, 23.

*Diagnosis*.—Subpentagonal productid having length roughly equal to width; pedicle valve generally with V-shaped median sulcus, surface ornamented by 24 to 35 costae and costellae and numerous scattered spines, including about 20 in area of hinge and ear. Brachial valve ornamented laterally and anteriorly by many short concentric frills.

*Description*.—Pedicle valve having greatest width usually at ears just in front of hinge. Valve convex throughout longitudinal profile; curvature greatest at umbo, decreasing a little unevenly but gradually toward anterior margin. V-shaped median sulcus (not quite central in holotype) present across hinge; in other specimens, area of sulcus is in some specimens, commonly beginning less than 5 mm in front of beak, which protrudes slightly across hinge; in other specimens, area of sulcus is

merely flattened or slightly depressed. Anterior and lateral slopes diverging toward margins. Umbonal slopes steep, diverging anteriorly at angle of roughly 110°, and curving outward gradually so that ears are only moderately delimited by broad diagonal sulci.

Surface of pedicle valve ornamented by somewhat irregular and subequal costae interspersed locally with costellae, generally averaging 30 in all but ranging from 24 to 35 in various specimens. Costae increasing by bifurcation, some tending toward fasciculation anteriorly. Rugae absent or merely suggested by two or three faint concentric ridges in umbonal region in some specimens; concentric growth lirae not prominent. Spine bases abundantly scattered over valve (1) on top of costae, commonly 1 to 2 mm apart over anterior slopes and 2 to 2¼ mm apart along individual costae, (2) in two rows or six or seven spine bases at either side of umbo, one along hinge margin, the other just in front at very low angle diagonal to hinge, extending on to ears, and (3) merging with cluster of about 12 to 15 spines scattered over umbonal and lateral slopes near ears.

Interior of pedicle valve (pl. 4, fig. 24) having low medial platformlike structure beginning 2 or 3 mm in front of umbo, as much as 3 mm wide, composed of two elongate smooth lobes divided by low median ridge; adductor muscle-scar area begins at its anterior end, occupying space 4 mm long and 1.3 to 1.7 mm wide between diductor muscle scars. Posterior pair of adductor muscle scars narrowly dendritic, diverging slightly posteriorly; anterior pair nearly smooth, situated in elongate parallel depressions opposite anterior parts of diductors. Diductor muscle scars occupying transversely oval longitudinally lirate areas 4 × 5 mm across, beginning 4 or 5 mm in front of beak. Rest of pedicle interior weakly costate; no endospines visible.

Brachial valve transversely subrectangular in outline, gently concave medioposteriorly, a little less concave in lateral areas a short distance in front of ears; also concave near anterior margin, except medioanteriorly where shallow fold, commonly present, corresponds to sulcus of pedicle valve. Surface ornamentation of fine radial costellae limited to initial part of valve, which is bounded by single tiny concentric frill approximately at middle of valve. Two or three more such frills with wide but gradually narrower interspaces surround first frill, and just within margin of valve is band of 7 to 10 concentric wavy frills; all appear to represent trails that never fully developed.

Interior of brachial valve (pl. 4, figs. 21, 25) having transversely suboval visceral disc bordered posteriorly by fairly short cardinal ridges that curve somewhat posteriorly at either side of cardinal process and die out laterally. Cardinal process short, typical of genus, but details of myophore not known. Posterior platform poorly defined high area that merges anteriorly with pair of low lobate adductor muscle-scar platforms, slightly raised anteriorly. Emerging from between platforms, brevisseptum extends almost to margin of visceral disc. Faint linear brachial ridges beginning near muscle-scar platforms at angle of 75° to brevisseptum, forming loop extending laterally and slightly forward, reaching edge of visceral disc anterolaterally. Short prostrate endospines in band along anterior margin of valve.

*Dimensions (in mm).—*

|                        | Holotype<br><sup>1</sup> UM 2645 | Paratypes                |         |
|------------------------|----------------------------------|--------------------------|---------|
|                        |                                  | <sup>2</sup> USNM 163760 | UM 2645 |
| Length -----           | 25.1                             | 23.5                     | 18.5    |
| Length along curvature | 41.0                             | 40.5                     | 32.5    |
| Greatest width -----   | 25.0                             | 23.5                     | 20.9    |
| Width of hinge -----   | 22.5                             | 18.5                     | 19.2    |
| Depth -----            | 13.3                             | 12.5                     | 9.7     |

<sup>1</sup> UM 2645 is from collection 36a.

<sup>2</sup> USNM 163760 is from collection E.

*Discussion.*—The description above is slightly modified from the original one, the greatest change being the addition of the internal characters of the brachial valve from a prepared topotype (colln. 27).

Two forms of this species are present in the Wind River Range. In the typical form (pl. 4, figs. 30–37), the narrow sulcus divides the vault of the shell into two rounded summits. In the nonsulcate form, the vault is rather flat across the top, curving abruptly into the sloping flanks. This gives the shell a distinctly trapezoidal aspect in posterior profile (pl. 4, figs. 26–20).

Gordon (1971) has pointed out the incorrect referral by Burk (1954) of two specimens of *C. amsdeniana* to the Middle Pennsylvanian (Des Moinesian) species *Marginifera muricatina* Dunbar and Condra. Burk's figured specimens have been re-examined. Both show the diaphragm area, which also can be seen in one of Burk's illustrations (Burk, 1954, pl. 1, fig. 28).

The species closest to *C. amsdeniana* is *C. phillipsi* (Norwood and Pratten), to which Branson and Greger (1918) originally referred the Wyoming form. *C. phillipsi* has fewer and coarser ribs and spines and a narrower hinge than *C. amsdeniana*, and it does not develop a V-shaped median sulcus in the pedicle valve, although it commonly possesses a

broad shallow sulcus or medial flattening in this valve.

*Stratigraphic considerations.*—*C. amsdeniana* is restricted to a single subzone, to which it gives its name, near the middle of the Horseshoe Shale Member in Fremont County. At Livingston Ranch it occurs in association with Formanifera of Mamet Zone 18. This agrees with the stratigraphic position of *C. phillipsi* in the Great Basin near the Utah-Nevada border, which occurs stratigraphically above beds containing corals of the *Caninia* Zone and below uppermost Mississippian beds containing Foraminifera of Mamet Zone 19.

*Types.*—Holotype and paratype, UM 2645; additional paratypes, USNM 163760–163763; hypotypes, UW A11094, A11119.

*Burk's figured specimens.*—UW IT-197, IT-198.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 22 (10+ fragments), 26b (3), 27 (11), 28 (8), ?29 (1), ?30 (1), 31 (6), 36a (29), 39 (3), 44 (2), 45 (2), 48 (2), E (27), Fremont County.

Family ECHINOCONCHIDAE Stehli  
Genus ECHINOCONCHUS Weller, 1914

*Echinoconchus* sp. A

Plate 3, figures 19, 23, 24, 31, 32

*Echinoconchus* aff. *E. alternatus* (Norwood and Pratten).  
Easton, 1962, p. 48, pl. 4, figs. 28a, b.

*Rugoclostus nivalis* Easton, 1962 [part], p. 60, 61, pl. 7, figs. 15a–d [not figs. 11–14].

*Description.*—Shell moderately large; pedicle valve subcircular in outline, greatest width occurring a little anterior to middle. Convexity in side profile greatest near umbo, decreasing gradually anteriorly, but continuing moderately convex to anterior margin. Subtrapezoidal in posterior profile, depressed over center, rounding strongly into sloping flanks that are very gently convex. Median part of valve flattened anteriorly over center and forming very shallow broad sulcus on anterior slope. Umbonal region elevated; umbo strongly incurved over hinge; umbonal slopes convex, very steep, diverging forward at angle of about 85°. Ears rather steeply inclined both posteriorly and laterally, merging with umbonal slopes. Interior of pedicle valve not known.

Ornamentation of pedicle valve consisting mainly of gently convex concentric ridges separated by narrow grooves, three to four ridges occurring in space of 1 cm on middle of anterior slope; bands narrowing and becoming slightly more elevated on flanks. Each concentric band bearing two or three rows of small spine bases from which emanate tiny forward-directed spines.

Brachial valve broadly oval to subquadrate in outline, gently concave, having very gentle broad poorly delimited median fold in anterior half; no apparent trail. Ornamentation of low concentric ridges, grooves, and spine rows as on pedicle valve, except that spacing tends to be closer, ridges averaging about 10 in 1 cm.

Interior of brachial valve with moderate-sized bilobate cardinal process, curving downward into beak of pedicle valve posteriorly. Cardinal ridges narrow, slightly recurved toward cardinal extremities. Posterior platform elevated above floor of valve, elongate, rounded above, merging anteriorly with adductor muscle-scar platforms which extend forward as a pair of narrow raised lobes; adductor muscle-scar impressions not identifiable. Brevisseptum narrow, extending from between muscle-scar platforms to point that is little more than halfway forward across valve. Anterior part of visceral disc bearing short prostrate endospines ranged along weak concentric ridges.

The figured nearly complete specimen (USNM 163788) which lacks a small part of the anterior margin has the following measurements (in mm): length 51, length along arch 95, maximum width 50 (twice the half width), width of hinge 36 (twice the half width), depth 30; its brachial valve is approximately 36 mm long and 4 mm deep.

*Discussion.*—Eleven specimens from six localities in the Rawlins hills are included under this title. They probably represent the same species illustrated by Easton (1962, p. 48) as "*Echinoconchus* aff. *E. alternatus* (Norwood & Pratten)" from a locality in the Cameron Creek Formation or Alaska Bench Limestone near Heath, Mont.

One of the paratypes of *Rugoclostus nivalis* Easton (1962, pl. 7, figs. 15a-d) also belongs in *Echinoconchus* and almost certainly in the same species that Easton illustrated from near Heath. The specimen in question (USNM 118790, from USGS colln. 13420-PC) consists of the posterior part of a pedicle valve and the cardinal process that was found imbedded in it and presumably came from the brachial valve of the same shell. The cardinal process is of a type of characteristic of *Echinoconchus*. The exterior of the pedicle valve, consisting of little more than the umbonal region, is ornamented by concentric bands, each bearing two or three rows of fine spines, the typical spine arrangement in *Echinoconchus* and particularly in *E. sp. A*.

The distinguishing characters of *Echinoconchus* sp. A are its very weak sulcate pedicle valve having a prominent overhanging beak; the concentric spine-

bearing ridges or slightly raised bands separated by narrow grooves, three to four occurring in the space of 1 cm on the middle of the anterior slope. The interior of the brachial valve is characterized by the prominent adductor muscle-scar platforms, merging posterior platforms, and the presence of a brevisseptum.

*Echinoconchus alternatus* (Norwood and Pratten) differs from *E. sp. A* in having a smaller shell, its pedicle valve ornamented by broad, moderately deep concentric depressions separated by narrow ridges, each depression bearing two or three alternating rows of spines with long spine bases; two depressions and two or three ridges generally occur in the space of 1 cm on an average specimen.

*E. vittatus* (Hall), which some workers have placed in synonymy with *E. alternatus*, has narrower concentric depressions but more spines, four or five rows occurring within a single concentric band; about three concentric depressions and ridges occur in the space of 1 cm on the middle of the anterior slope, becoming more crowded toward the anterior margin. The beak is shorter and less incurved than that of *E. sp. A*, and the median sulcus in the pedicle valve is well defined. Within the brachial valve of *E. vittatus*, a median septum extends forward from the cardinal process, although it may be partly covered with secondary shell material in old age, and the adductor muscle-scar platforms are ill-defined longitudinal lobes.

It seems likely that *Echinoconchus* sp. A. represents an unnamed species, but our material is not quite well enough preserved to serve as primary type specimens.

*Figured specimens.*—USNM 163788, 163789.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 1 (1), 3 (4), 5 (2). Ranchester Limestone Member: collections 6 (2), 13 (1), ?14 (1), Carbon County.

Family BUXTONIIDAE Muir-Wood and Cooper  
Genus FLEXARIA Muir-Wood and Cooper, 1960

*Flexaria* sp.

Plate 3, figures 28-30

*Pustula genevievensis* (Weller). Branson and Greger, 1918, p. 315, 316, pl. 19, fig. 1.

A pedicle valve, figured by Branson and Greger, is the only undoubted *Flexaria* known from the Amsden Formation. The shell is 23.3 mm long, 25.5 mm wide, and 12.0 mm deep. The hinge line, broken at its extremities, is not quite 17 mm long; it is estimated to have been approximately 19 mm in length. The valve has the characteristic rounded-subtrapezoidal outline of *Flexaria*, the greatest width

occurring slightly anterior to the middle. The umbo protrudes a millimeter or two beyond the hinge; the greatest convexity in side view is near the umbo, particularly at points 5 and 9 mm, respectively, anterior to the tip; the rest of the valve is rather regularly convex to the anterior margin. The apical angle is approximately  $110^\circ$ , and the lateral slopes diverge at an angle of  $65^\circ$ . In posterior view, the valve is rather flat over the visceral disc, and the lateral slopes are steep. What resembles a shallow ventral sulcus in the posterior part of the valve appears to be in part pathologic; no marked sulcus is present on the anterior half of the valve, but a faint slightly asymmetric depression indents the anterior margin.

The surface of the shell is ornamented by about 55 rounded costae and costellae; near the anterior margin an average of 7 of these occur in the space of 5 mm. Costae and costellae are thickened locally, particularly where they give off anteriorly directed spines; some of the spine bases near the anterior margin tend to be aligned in concentric rows.

Only figure 1 of the two figures that Branson and Greger (1918, pl. 19, figs. 1, 2) identified as *Pustula genevievensis* (Weller) is actually a view of this shell. The other figure so labeled (fig. 2) is a side view of the productoid they also illustrated in figure 5 of the same plate, which they identified as *Dia-phragmus phillipsi* (Norwood and Pratten) and which has since been designated the holotype of *Carlinia amsdeniana* Gordon.

Presence of costae and absence of concentric ridges preclude assignment of this shell to *Echinoconchus*, the genus to which "*Pustula*" *genevievensis* (Weller) originally was and should presently be referred. Resemblance of this Amsden shell is closer to *Juresania* than to *Echinoconchus* because of its concentric rows, but the more or less continuous costae and the relatively small number of concentric grooves is more compatible with *Flexaria*. Another specimen, from Livingston Ranch, is referred with question to *Flexaria*.

*Figured specimen*.—UM 2646.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 36a (1), ?45 (1), Fremont County.

Genus JURESANIA Fredericks, 1928

*Juresania* sp.

Plate 3, figures 25–27

This record is based on seven specimens in six collections. The figured pedicle valve (USNM 163772) is 23.5 mm long, 25 mm wide near the anterior end, and 12.5 mm deep. The hinge appears

to have been somewhat narrower than the widest part of the shell. In side elevation the greatest curvature is at the umbo; the convexity decreases gradually toward the anterior margin. In posterior view, the valve is flat to slightly depressed over the visceral disc and rounds rapidly to the lateral slopes, which are very steep. A broad shallow median sulcus begins about 10 mm in front of the umbo and continues to the anterior margin. The sides of the umbo diverge at about  $90^\circ$ , and the lateral slopes, at  $70^\circ$ .

Surface sculpture in the pedicle valve consists of slightly concave concentric bands bordered by narrow shallow ridges. These bear elongate spine bases, many of which resemble interrupted costae; six or seven of these occur in a space of 5 mm on the anterior slope. Spines emanate in a single row near the anterior edge of each concentric band. Near the anterior margin the spines are somewhat random in their distribution. On a fragmental pedicle valve (USNM 163773) better preserving the sculpture of the posterior part of the shell, the concentric bands are narrow and more numerous, and the spine bases emanate from single rows of shallow nodes ranged along the concentric ridges.

The figured brachial valve (USNM 163771) is fairly flat, having a faint shallow median fold externally on its anterior half and a short trail. It is 19 mm long, 23 mm wide, 3 mm deep, and its hinge is 18 mm long (determined as twice the half width). Its interior is well preserved as a mold in dolomite. The cardinal ridges are narrow and fairly shallow, diverging in a broad obtuse angle from the base of the cardinal process. A pair of short longitudinal ridges or buttress plates with an elongate antron between them support the cardinal process (which is missing in this specimen). Immediately in front of these the posterior platform is narrow, slightly elevated, and gives rise to a short brevisseptum that bisects a pair of elongate lobate muscle-scar platforms, slightly raised anteriorly; these extend forward to a point about two-fifths of the way across the visceral disc. Anterior to this, a series of six concentric ridges bears one or two rows each of small endospines. Brachial ridges are not visible.

The specimens referred here to *Juresania* sp. differ from *Flexaria* sp. of the Horseshoe Shale Member in having the surface of the shell ornamented by concentric bands each bearing a row of elongate spine bases, instead of fairly continuous costae and costellae.

This species differs from *Juresania nebrascensis*



(Owen) in its slightly narrower shape, in having well-defined concentric bands in both valves, a short delicate brevisseptum in the brachial valve, and narrow lobate adductor muscle-scar platforms instead of a markedly dendritic posterior pair of adductor muscle scars and short rounded raised platforms supporting the anterior pair of muscle scars. The Amsden species differs from *J. symmetrica* (McChesney) in its smaller size, narrower shape, stronger concentric ribbing, more elongate spine bases, and fewer spines. Differences from *J. ovalis* Dunbar and Condra are approximately the same, except that the shape of the shell is more similar.

The Amsden shells probably belong in a new species, but the material at hand is not considered sufficient for erection of a new name.

*Figured specimens*.—USNM 163771, 163772.

*Mentioned specimen*.—USNM 163773.

*Occurrence and number of specimens*.—Horseshoe Shale Member, collection 54 (1), Johnson County. Ranchester Limestone Member: collections 52 (2), Johnson County; 100 (1), Lincoln County; 134 (1), Sublette County; 141 (1), 142 (1), Teton County.

Family DICTYOCLOSTIDAE Stehli

Genus ANTIQUATONIA Miloradovich, 1945

*Antiquatonia blackwelderi* n. sp.

Plate 5, figures 10–19

*Diagnosis*.—Moderately large, shallowly sulcate dictyoclostid having slight geniculation over middle of pedicle valve and strong geniculation at edge of visceral disc in brachial valve. Posterior slope strongly reticulate; costae on anterior part of valve fairly regular. Adductor muscle-scar platforms in brachial valve massive, depressed medially, and inclined posteriorly.

*Description*.—Shell moderately large; pedicle valve transversely suboval to subtrapezoidal in outline; ears large so that some shells are widest at hinge. In side view valve appears well rounded, greatest convexity occurring in umbonal region, gradually lessening anteriorly except over middle of visceral disc where slightly increase in convexity occurs; trail gently convex to flat. In posterior view, valve appears highly arched, generally indented medially by moderately deep to shallow sulcus beginning 10 to 20 mm in front of beak; lateral slopes steeply inclined; umbonal slopes also steep, diverging at angle normally of 110°. Umbonal region set off from moderately arched ears by diverging sulci at base of umbonal slopes. On slope within or just above each lateral sulcus is curved diagonal spine-bearing ridge. Beak protruding slightly beyond hinge.

Surface sculpture of pedicle valve consisting of costae, rugae, and spines. Costae beginning at umbo and extending to anterior margin, increasing by bifurcation, are rounded and separated by subequal rounded intercostal grooves, four or five occurring in space of 5 mm on anterior slope. Rugae on posterior one-third of valve are slightly wider but usually slightly weaker than costae; fine concentric growth lines also present. Moderately erect hollow spines scattered over shell; on anterior slope, spine bases are wider than costae and spaced 8 to 13 mm apart. Row of five or six spines follows along top of diagonal ridge on each flank above ears, spines increasing in size anteriorly; row curving downward just beyond end of ridge. Row of seven smaller spines present along posterior margin at angle of 20° to hinge; spines in both rows directed posteriorly and slightly downward. Spine row on each flank at angle of 45° to hinge.

Interior of pedicle valve having slightly raised adductor muscle-scar platform beginning about 12 mm in front of umbo and extending forward 12 to 15 mm; reaching 8 mm in width, platform narrows and tapers off at anterior end. At either side of platform, pair of indistinct subtriangular longitudinal grooved diductor muscle scars, roughly 15 mm long and 15 mm wide, fans out anteriorly; anterior part of trail studded within with fine closely spaced endospines.

Brachial valve flat posteriorly and gently concave anteriorly, but medially gentle fold, corresponding to medial sulcus of pedicle valve, continues on to trail. Each cardinal extremity set off by short diagonal ridge; along margin of visceral disc valve appearing rounded, almost geniculate; trail approximately straight. Ornamentation in brachial valve consisting of costae, rugae, and growth lines, similar to those on pedicle valve, but no spines present.

Interior of brachial valve having pair of sharp cardinal ridges, curving slightly backward toward cardinal process; other end terminating rather abruptly at cardinal extremities. Cardinal process of linoproductid type, appearing massive on top, almost sessile; myophore triangular, approximately vertical, trifid, having double-ridged middle lobe, lobes converging downward. Posterior platform of moderate width, subtriangular in cross section, terminating above in low median septum that extends forward from cardinal process. Adductor muscle-scar platforms massive, outer edge formed by two thick raised ridges, highest just in front of middle, inclined posteriorly, merging with poste-



rior platform and terminating anteriorly in two narrow low subtriangular lobes. Posterior pair of adductor muscle scars crudely dendritic, occupying depressions within and at rear of muscle-scar platforms; anterior pair smaller and fairly smooth. Emerging from between muscle-scar platforms, median septum is higher, bladelike, crossing visceral disc almost to anterior edge. Brachial ridges extending from just in front of middle of adductor muscle-scar platforms outward, beginning at angle of 80° to median septum, curving forward, then along edge of visceral disc, and finally recurving toward muscle-scar platform. Fine endospines marking anterior part of trail.

*Dimensions.*—Although none of our specimens is suitable for accurate measurement, an average-size specimen, 40 mm long, has a maximum width of roughly 46 to 48 mm and depth of approximately 25 mm.

*Discussion.*—This species is named in honor of Eliot Blackwelder, whose pioneering work on the geology of western Wyoming contributed greatly to the knowledge of this region and who collected some of the specimens studied. The description above is based on specimens collected by Blackwelder in the Gros Ventre Range, supplemented by material from Hoback Canyon which has added information on the internal characters of both valves. All the occurrences of *A. blackwelderi* in the Amsden Formation are in beds of Morrowan equivalence, as indicated by other megafossils and by microfossils.

*Comparisons and affinities.*—*Antiquatonia blackwelderi* is distinguished from *A. coloradoensis* by its somewhat larger shell having wider and more prominent ears, generally coarser costation, and by its wider and longer but generally less elevated adductor muscle-scar platform in the pedicle valve.

*A. blackwelderi* appears closest to *A. hermosana* (Girty), but the Colorado species is more evenly convex, both in side and posterior profile, lacks the tendency toward geniculation in the pedicle valve and rather strong geniculation at the edge of the visceral disk in the brachial valve of *A. blackwelderi*. *A. hermosana* also has slightly coarser and less regular costae that tend to bifurcate freely on the anterior and anterolateral slopes, increasing the number of costae a little faster than available space can accommodate them, so that a rude bunching or fasciculation of the costae commonly occurs. The internal characters of *A. hermosana* are as yet poorly known.

*Types.*—Holotype, USNM 163774; paratypes, USNM 163775–163780 (10 paratypes).

*Occurrence and number of specimens.*—Ranchester Limestone Member: collections 83 (4), 84 (2), 100 (3), Lincoln County; 130 (4), 131 (12), 136 (1), 139 (5), 141 (1), 143 (fragment), Teton County; 133 (3), 134 (8), Sublette County.

*Antiquatonia* cf. *A. coloradoensis* (Girty)

Plate 5, figures 1–9

*Productus inflatus* McChesney. Girty, 1903, p. 359–361, pl. 3, figs. 1–3.

*Productus inflatus*? Girty, 1904, pl. 11, figs. 5, 6; Boutwell, 1912, pl. 6, figs. 3–4.

*Productus inflatus* var. *coloradoensis* Girty, 1910, p. 215; 1920, pl. 55, figs. 3, 4.

*Productus coloradoensis* Girty. Girty, 1927, pl. 27, fig. 17; 1935, p. 7–9, pl. 2, figs. 1–4.

*Dictyoclostus coloradoensis* (Girty). Sutton, 1938, p. 563.

*Antiquatonia coloradoensis* (Girty). Stehli, 1954, p. 317; Muir-Wood and Cooper, 1960, p. 272; Hoare, 1961, p. 57–59, pl. 7, figs. 6–9; Stevens, 1962, pl. 95, figs. 2, 3, 5.

*"Dictyoclostus" inflatus* (McChesney). Easton, 1962 [part], p. 52–54 (locs. 13382–PC, 13403–PC, 13404–PC, 13421–PC, 13423–PC).

*Antiquatonia pernodosa* Easton, 1962 [part], p. 58, 59 [not pl. 7, figs. 6–8] (locs. 13421–PC, 14220–PC).

*"Buxtonia" arizonensis* Hernon. Easton, 1962 [part], p. 62 [not pl. 8, figs. 5, 6] (locs. 13404–PC, 13421–PC).

*Lectotype of Productus coloradoensis Girty.*—Some confusion has resulted from the fact that Girty described this Pennsylvanian species in a paper on the Late Mississippian fauna of the Fayetteville Shale of Arkansas (Girty, 1910, p. 215, 216) as a variety of *Productus inflatus* McChesney. This has caused some authors to cite Mississippian shells under this name. Girty stated clearly, however, that he was erecting the name *coloradoensis* for the western shells he had described and figured as *P. inflatus* in his Colorado report (Girty, 1903, p. 359–361, pl. 3, figs. 1–3). Three specimens from one locality were used in illustrating this species; these are syntypes of *P. coloradoensis*.

The desirability of selecting a lectotype from these specimens has been called to my attention by J. L. Carter. I therefore designate the specimen illustrated by Girty (1903) on his plate 3, figures 1 to 1b, as the lectotype. This specimen is USNM 35345 in the type collection of U.S. National Museum and measures (in mm): length 36.5, length along arch 69, maximum width 41, and convexity 24.5. Figured paralectotypes are the specimens illustrated on the same plate in figures 2, 2a (USNM 121482) and 3 (USNM 121483). Unfigured paralectotypes include

11 specimens numbered USNM 8258 and 5 specimens numbered USNM 11660, all from the same locality as the figured primary types.

The type locality for *Antiquatonia coloradoensis* (Girty) is USGS locality 2281 (old register—specimens marked by green paper tabs). Published and hitherto unpublished data place this locality on the crest of the ridge south of Four Mile (Horseshoe) Creek, about 2 miles east of Horseshoe Mountain and 8 miles west-southwest of Fairplay, Colo. (This locality would be approximately in the NE $\frac{1}{4}$  sec. 18 (unsurveyed), T. 10 S., R. 78 W., Park County, Colo., at an altitude slightly higher than 12,400 feet.) The collection was made from Weber Shale?, bed 38 (or 39) of measured section 18 (Peale, 1874, p. 229). The collector was A. C. Peale in July 1873. Bed 38 was described as a unit of limestone and bluish argillaceous shale with sandstone, 57 feet thick. The productoids were reported to come from its upper part. Bed 39 consisted of 34 feet of black shaly limestone. The precise locality of the collection needs verification.

*Wyoming material.*—Shells from two Pennsylvanian localities (three collections) in the northern part of the Bighorn Mountains and three in the Rawlins hills are included in this category. The Wyoming specimens are, for the most part, poorly preserved and worn, and many are distorted. The characters of the Wyoming specimens include an inflated pedicle valve, having small to moderate-sized ears and a rather evenly decreasing curvature in side profile. The sculpture consists of costae and costellae, of which six to eight occur in the space of 5 mm on the middle of the visceral disc and five or six, rarely seven, in 5 mm along the anterior margin. These characters are roughly those of *A. coloradoensis*. In contrast to Girty's Colorado species, all the primary types of which have a shallow median sulcus in the pedicle valve, most of the Wyoming specimens are without a sulcus.

The shell illustrated on plate 5, figures 6–9, is the most complete and best preserved of our specimens, but it is a pathologic individual, showing damage in the form of a longitudinal trough in the middle of the brachial valve which appears as a ridge on the anterior slope of the pedicle valve. The finely reticulate posterior part of the pedicle valve is well shown in this shell, which has the following dimensions (in mm): length 27, length along arch 52, greatest width 36, width at hinge (twice the half width) 29?, and convexity 18.

An internal mold in chert (pl. 5, fig. 4) shows the adductor muscle-scar platform on the interior

of the pedicle valve. This begins about 10 mm in front of the umbo and is 9 mm long; it averages 3 mm wide throughout most of its length but is 5 $\frac{1}{2}$  mm wide at its anterior end. Both the adductor and diductor muscle scars are not clearly defined on this specimen.

Internal characters of the posterior part of the brachial valve are shown on a fragment from a limestone bed of Atokan age in the Rawlins hills (pl. 5, fig. 5). The cardinal process is massive, trifid posteriorly, and almost sessile against the thick elevated cardinal ridges; these ridges are inclined posteriorly and extend strongly almost to the cardinal extremities, near each of which a short diagonal ridge splits off. The median septum is shallow and indistinct over the posterior platform but extends forward past midlength from between the pair of medium-sized adductor muscle-scar platforms, which are subtriangular and somewhat elevated anterolaterally. The middle of the valve adjacent to the muscle-scar platform is irregularly pitted.

*Discussion.*—Similar shells occur in the Tyler Formation and Alaska Bench Limestone in central Montana. These include specimens identified by Easton (1962, p. 53, 59, 62) as "*Dictyoclostus*" *inflatus* (McChesney), the type of species of *Inflatia* Muir-Wood & Cooper; *Antiquatonia pernodosa* Easton; and "*Buxtonia*" *arizonensis* Hernon. The Montana collections in which these occur are listed in the synonymy. Some of these specimens also lack a median sulcus. Our reevaluation of the Carboniferous faunas of central Montana indicates that neither *Inflatia* nor any genus of buxtonids is presently known in the Tyler Formation and Alaska Bench Limestone.

The antiquatonias of the Amsden of Wyoming and Montana may belong in a subspecies of *A. coloradoensis* that differs from the typical form in generally lacking a sulcus in the pedicle valve. Such a decision, however, cannot be based on the poorly preserved Wyoming material and the sparse and rather incomplete Montana material.

Restudy of the Montana material has shown also that *Antiquatonia pernodosa* Easton is a somewhat smaller species than *A. coloradoensis* and is restricted to the Big Snowy Group of Late Mississippian age. The sulcus is prominent in this species, the sculpture slightly coarser than in typical *A. coloradoensis*, and the spine pattern is different. As is typical in Mississippian antiquatonias, the row of spines above the notch on each flank is fairly straight and appears continuous with a row of moderately large spines that crosses the middle of

the anterior slope. This character is also present in *A. antiquatus* (Phillips), the type of species of *Antiquatonia*. In the Pennsylvanian forms, by contrast, the spines in a row above the notch increase rapidly in size, and the row curves around the ear and tends to follow the direction of the costae. This is the pattern found in *A. coloradoensis*.

*Types*.—Lectotype, USNM 35345; paralectotypes, USNM 8258, 11660, 121482, 121483.

*Figured specimens*.—USNM 163782–163785.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 5 (1), Carbon County; 53 (1), Johnson County. Ranchester Limestone Member: collections 6 (45), 13 (5), 15 (7), Carbon County; 67 (1) 68 (1), Sheridan County.

#### *Antiquatonia* sp.

Fragments of medium-sized pedicle valves from limestone beds in the Covey Cutoff section and at Soda Creek are referred to *Antiquatonia* on the basis of shape, costation, and what can be seen of the spine arrangement. This Mississippian material is too poor for one to determine whether or not they belong in *Antiquatonia pernodosa* Easton or some other species. The Late Mississippian antiquatonias in the United States have not been adequately studied and described. In the Great Basin of Nevada and Utah (the Mississippian productoids of which are under study by the writer), *Antiquatonia* is locally abundant, ranging upward from beds of late Meramecian age.

*Mentioned specimens*.—USNM 163787.

*Occurrence and number of specimens*.—Moffat Trail Limestone Member: collection 93 (3), Lincoln County. Horseshoe Shale Member: collection ?41 (1), Teton County.

Family LINOPRODUCTIDAE Stehli  
Genus OVATIA Muir-Wood and Cooper, 1960

*Ovatia croneisi* (C. Branson)

Plate 6, figures 1–6

*Linoproductus croneisi* C. Branson, 1937, p. 656, pl. 89, figs. 13–15; Sutton, 1938, p. 558; ?Easton, 1962 [part], p. 50, 51, pl. 6, fig. 9.

*Cancrinella boonensis* (Swallow). Burk, 1954, p. 10, pl. 1, fig. 35.

*Ovatia croneisi* (C. Branson). Muir-Wood and Cooper, 1960, p. 298.

*Diagnosis*.—Moderately large, broadly arched linoproductid having rather low umbonal region and shallow visceral cavity. Both valves ornamented by 30 to 36 capillae in space of 1 cm; pedicle valve with double spine row along hinge.

*Description*.—Pedicule valve transversely oval in outline, greatest width occurring a little in front of hinge (cardinal extremities broken off in de-

scribed adult specimen). Convex in side profile, curvature decreasing gradually from umbo forward. In posterior profile broadly arched over visceral disc, flanks sloping, gently convex. Umbonal region depressed to moderately convex; umbonal slopes gently convex, sloping, poorly delimited, diverging roughly at right angle from umbo, lower part of slopes concave, rounding gradually into ears, forming broad diagonal sulci. Beak protrudes very slightly across hinge line.

Ornamentation of pedicle valve consisting of fine, slightly flexuous capillae, narrowly rounded and separated by slightly narrower to slightly wider grooves; capillae increasing by intercalation. A few weak rugae present over posterior part of visceral disc, strongest on sides and near hinge, and strengthening slightly towards cardinal extremities, but not becoming markedly stepped. Fine, almost microscopic growth lines also present. Spines small, occurring (1) in double row along hinge, two or three also scattered just in front of this double row, at either side of diagonal sulci, and (2) as small anteriorly inclined spine bases scattered over slopes 4 to 6 mm apart.

Brachial valve concave, having a little less curvature than pedicle valve. Visceral cavity reaching maximum height of about 4 mm. Ornamented by fine bifurcating capillae similar in strength and spacing to those of pedicle valve; weak concentric grooves over visceral disc. Spine bases not observed. Internal characters of brachial valve not known.

Dimensions of specimen UW A1281 (in mm) are as follows: Length 30.5, length along arch 45, maximum width 40, and depth 27.5. Specimen is not complete but is the largest available.

*Discussion*.—Branson described this species from immature and fragmental specimens weathered out at Cherry Creek. The holotype, 10 mm long by 10.5 mm wide, (pl. 6, figs. 4–6) the paratypes, and subsequently collected topotypes all have low convexity and a very shallow visceral cavity. The most complete specimen to come to light, a topotype preserved in sandstone in the University of Wyoming collection, has been the main source of the adult characters in the foregoing description and is illustrated on plate 6, figures 1–3. Although this specimen is somewhat more inflated posteriorly than the shells preserved in shale, the spacing and strength of the capillae and the details of the spine bases indicate that the same species is represented. The relatively low convexity of the posterior part of the shell, the very shallow visceral cavity, and the capillate ornamentation and rather sparsely

scattered small spines are the distinguishing characters of this species.

Specimens from central Montana identified by Easton as *Linoproductus croneisi* Branson probably do not belong in *O. croneisi*, with the possible exception of the one figured by Easton (1962, pl. 6, fig. 9), and even it should be questioned. All are more convex than typical *O. croneisi*. The species from the Cameron Creek (USGS colln. 13382-PC), represented by five specimens, is a small rather deeply convex highly spinose form having prominent rugae and very low capillae; it certainly should not be assigned to *O. croneisi*. One specimen from the Heath Shale (USGS colln. 13360-PC) is incomplete and could be a variant of *O. duodenaria* (Easton) with slightly finer costellae than is normal for that species.

*O. croneisi* has been identified at Cherry Creek and South Pass in the Wind River Range. Crushed specimens from Berry Creek in the Teton Range are referred with question to this species.

*Types*.—Holotype and paratypes, UM 6831; hypotype UW A1281.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 22 (3), 26b (1), 27 (1), 31 (1), ?34 (1), 36d (8), Fremont County; ?149 (2), ?152 (2), ?155 (1), Teton County.

*Ovatia muralis* n. sp.

Plate 6, figures 7-17

*Linoproductus prattenianus* (Norwood and Pratten). Burk, 1954, p. 9, 10, pl. 1, figs. 36, 37.

*Diagnosis*.—Small- to medium-sized linoproductid, length approximately equal to width, having rather elevated umbonal region; cardinal extremities approximately rectangular; flanks almost vertical. Longitudinal ornamentation of 20 to 25 costellae in space of 1 cm on anterior slope. Double row of spines along hinge, two or three large ones near cardinal extremities.

*Description*.—Shell of moderate size; pedicle valve subquadrate to subpentagonal in outline, length approximately equal to width; greatest width occurring at or slightly anterior to middle of shell; cardinal extremities forming angles that approximate 90°. In side profile, curvature decreasing gradually from umbo, cut convex to anterior margin. In posterior profile, strongly convex over visceral disc; flanks approximately vertical dorsad of plane extending concentrically forward from ears, merging gradually with anterior slope. Umbonal region elevated, its slopes convex, steep, diverging anteriorly at angles of 85°-90°, rounding rather strongly toward ears forming diagonal sulci along base of um-

bonal slopes. Beak protrudes slightly across hinge line.

Interior of pedicle valve poorly known; adductor muscle-scar platform indistinct. Diductor muscle scars longitudinally grooved, set in shallow sub-oval depressions roughly 7 mm long and 10 mm wide, beginning about 12 mm in front of umbo in mature specimen.

Ornamentation on pedicle valve of straight to slightly flexuous narrowly rounded costellae, increasing by intercalation, separated by narrow intercostal grooves; on early parts of shell, within 10 mm of umbo, 12 to 14 costellae occur in space of 5 mm; on mature parts of shell 10 to 12 costellae occur normally in space of 5 mm. Concentric wrinkles present on umbonal slopes and ears, rather steplike in appearance toward cardinal extremities; at outermost of these, shell bends abruptly into nearly vertical flanks. Spines occurring (1) in double row of fine spine bases along hinge, two or three large spines occurring at cardinal extremities, (2) elliptical spine bases scattered sparingly over valve, reaching 2 mm in length by 1 mm in width on anterior slope.

Brachial valve rather deeply concave; visceral cavity reaches height of as much as 9 mm in adult shells. Details not preserved.

*Dimensions (in mm) of four pedicle valves are as follows*.—

|                     | USNM<br>1 163791 | USNM<br>2 163795 | USNM<br>1 163792 | USNM<br>1 163793 |
|---------------------|------------------|------------------|------------------|------------------|
| Length -----        | <sup>3</sup> 34  | 19.5             | 9.2              | 5.9              |
| Length along arch - | —                | 35               | 15               | 9                |
| Maximum width --    | 35               | 21               | 8.2              | 6.2              |
| Width of hinge --   | 30.5             | 19               | 6                | <sup>4</sup> 6   |
| Depth -----         | 24               | 13               | 5.5              | 4                |

<sup>1</sup> USNM 163791-163793 are from collection 93.

<sup>2</sup> USNM 163795 is from collection 45.

<sup>3</sup> Estimated.

<sup>4</sup> Twice the half width.

*Discussion*.—This description is based on specimens from the Covey Cutoff section, two of which are figured (pl. 6, figs. 7-10, 15-17). They occur in association with *Diaphragmus cestriensis* (Worthen) at that locality and at Hoback Canyon.

The distinguishing characters of *O. muralis* are its moderate-sized shell of subequal length and width, its strongly convex umbonal region, the spacing of the costellae 10 to 12 in 5 mm, the prominent longitudinal elliptical spine bases and, most important, the subquadrate ears that recurve abruptly into the nearly vertical flanks.

The figured specimen from Livingston Ranch (pl. 6, figs. 11-14), differs from those from the type locality only in being somewhat flatter over the visceral disc, but this slight depression of the

central part of the valve might have taken place after burial. Two specimens from Horse Creek, referred to this species with some question because of rather poor preservation, were figured by Burk (1954, pl. 1, figs. 36, 37) as *Linoproductus prat-tenianus* (Norwood and Pratten).

This species differs from *O. croneisi* in having a more elevated and convex umbonal region, slightly coarser costation, larger and more prominent spine bases, and very steep, rather straight flanks. Immature specimens of *O. muralis*, consisting of little more than the beak and part of the visceral cavity, can be distinguished easily from similar specimens of *O. croneisi*, which has very low convexity initially and a visceral cavity of exceedingly limited height.

*O. duodenaria* (Easton) has a smaller shell, forming a lower arch over the visceral disc, having a narrower hinge, and lacking the steep vertical flanks of *O. muralis*.

*Types*.—Holotype, USNM 163791; paratypes, USNM 163792–163795.

*Occurrence and number of specimens*.—Moffat Trail Limestone Member: collections 93 (12), Lincoln County; 121 (1), 122 (1), Teton County. Horseshoe Shale Member: collections 743 (2), 45 (1), Fremont County.

#### Genus LINOPRODUCTUS Chao, 1927

*Linoproductus eastoni* n. sp.

Plate 6, figures 18–31

*Linoproductus nodosus* (Newberry), n. subsp. Easton, 1962 [part], p. 50, pl. 6, figs. 6–8b.

*Diagnosis*.—Moderate-sized *Linoproductus* having large umbo and extended flaring trail ornamented by 18 to 28 costellae and capillae in space of 1 cm; single row of spines along hinge in pedicle valve at 10° angle to hinge; coarse spines scattered over anterior slope. Brachial valve deeply concave over visceral disk.

*Description*.—Pedicle valve elongate-oval in outline, widening anteriorly, greatest width near or somewhat anterior to middle. Curvature in side profile decreasing gradually but slightly unevenly from umbo, remaining convex over visceral disc; trail somewhat variable in curvature, gently convex to straight, locally concave. Posterior profile subtrapezoidal, gently convex medially over visceral disc, rounding more strongly at either side into inclined flanks, which are gently convex to straight. Umbonal region elevated, prominent, rather elongate; umbo incurved over hinge; umbonal slopes steep,

rounding rather abruptly into ears; apical angle 110°, umbonal slopes diverging, a little further forward, at approximately 85°. Hinge fairly short on most shells with more extended hinge, cardinal extremities are rectangular to subacute. Trail flaring anteriorly, on some specimens forming weak fold near anterior margin (pl. 6, fig. 30). Interior of pedicle valve not known.

Ornamentation of pedicle valve consisting of rounded costellae, somewhat flexuous and increasing by intercalation, separated by subequal rounded intercostal grooves; typically 9 to 11 costellae occur in space of 5 mm. Coarse wrinkles present on umbonal slopes and flanks, strengthening toward ears; not crossing ventral part of valve. Spines (1) occurring in a row of four or five prominent spine bases increasing in size toward ears and diverging at angle of 10° to hinge line at either side of umbo, (2) of two types scattered over anterior part of visceral disc and on trail, large erect spines arising from spine bases as much as 3 mm long and 1.5 mm wide, bearing spines as much as 1.5 mm in diameter near base, concentrated in middle part of anterior slope (costellae converging and tending to merge in front of large spine bases), and smaller anteriorly inclined spines emerging from individual costellae, more common toward flanks.

Brachial valve deeply concave, rounding into long trail; visceral disc transversely oval, rarely subcircular, steepening rapidly at sides where steplike wrinkles correspond to those in pedicle valve. Ornamentation of brachial valve of bifurcating costellae, similar in strength and spacing to those on pedicle valve. Spines were not observed.

Interior of brachial valve having strongly convex visceral disc; posterior platform broadly rounded, merging with convex valve floor, supporting short sessile cardinal process; myophore bilobate above and trilobate posteriorly, having broad deeply sulcate median lobe giving myophore quadrilobate appearance; shallow alveolus present on some specimens. Cardinal ridges emanating from base of cardinal process and diverging at angle of 20° to hinge line, dying out on floor of valve about halfway toward cardinal extremities. Median septum bladeli-like, merging with anterior part of posterior platform and extending roughly two-thirds of way forward across visceral disc. Adductor muscle scars indistinct, weakly dendritic where visible, set on slightly thickened subtriangular areas at either side of median septum.

*Dimensions (in mm).—*

|                                       | Pedicel valves |                |                | Brachial valves |                |
|---------------------------------------|----------------|----------------|----------------|-----------------|----------------|
|                                       | USNM<br>163797 | USNM<br>163801 | USNM<br>163796 | USNM<br>163798  | USNM<br>163800 |
| Length -----                          | 43             | 30             | 46             | 39              | 31.5           |
| Length along arch                     | 74             | 46             | 68             | 60              | 51             |
| Maximum width --                      | 46             | 31             | 45             | 44              | 31             |
| Width of hinge --                     | 34             | —              | 33             | 35              | 20             |
| Maximum width of<br>visceral disk --- | —              | 25             | 31             | 29              | 19             |
| Depth -----                           | 28             | 16             | 22             | 18              | 16             |

<sup>1</sup> Primary types USNM 163796-163798 are from USGS collection 16177-PC.

<sup>2</sup> Primary type USNM 163800 is from collection 54.

<sup>3</sup> Primary type USNM 163801 is from collection 53.

<sup>4</sup> Trail incomplete and distorted by compression.

<sup>5</sup> Trail incomplete but undistorted.

*Discussion.*—The species is based primarily on specimens from the Big Snowy Mountains in central Montana. It also is fairly common in the Ranchester Limestone Member at various localities in Wyoming; two paratypes from the Bighorn Mountains are illustrated (pl. 6, figs. 18, 22, 23, 27, 28). The Bighorn Mountains specimens are a little smaller and more finely costate than those from Montana, some having locally as many as 28 costellae and capillae in a space of 1 cm, but otherwise have all the distinguishing characters of typical *L. eastoni*.

The same species was described by Easton (1962, p. 50) under the name "*Linoproductus nodosus* (Newberry), n. subsp." Most, if not all, of Easton's specimens from the Cameron Creek Formation and Alaska Bench Limestone belong in *L. eastoni*, but not those from the Heath Formation which include specimens ornamented by capillae as in *Ovatia croneisi*.

None of the Montana-Wyoming shells belongs in Newberry's species. *L. nodosus* is identified by a row of spines along the median plane of the pedicle valve. *L. eastoni* differs from *L. nodosus* in having spines scattered randomly over the surface of the pedicle valve, in having a longer trail, and in being somewhat flatter over the ventral disc in the pedicle valve. The highly convex visceral disc in the interior of the brachial valve and long flaring trail, with a faint median fold on some pedicle valve, are characters that also serve to distinguish *L. eastoni*.

*L. eastoni* differs from *Ovatia croneisi* in having slightly coarser costation, but the costellae of *O. muralis* have about the same strength and spacing as in some specimens of *L. eastoni*. The distinctive shape of *L. eastoni*, particularly the subtrapezoidal posterior outline and flaring trail distinguish it readily from the more evenly arched Mississippian ovatis with their relatively short trails.

*Type locality.*—The type lot was collected at USGS locality 16177-PC in Stonehouse Canyon,

Golden Valley County, Mont., in 1955, while I was there on a field trip with W. H. Easton, L. S. Gardner, P. E. Cloud, and R. J. Ross. The linoproductids, in association with *Rugosochonetes pseudoliratus* (Easton) and *Antiquatonia "pernodosa"* Easton, came from 1 foot of buff-gray calcareous siltstone near the middle of unit 22 of Easton's published section (Easton, 1962, p. 122) at that locality, which is in the SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 31, T. 11 N., R. 21 E. This unit was assigned to the Alaska Bench Limestone in the published sections but cited as Cameron Creek Formation in the paleontological part of the report. In the field, Easton placed the collection 3 feet below the base of the Alaska Bench Limestone. Maughan and Roberts (1967, pl. 4) also placed the collection in the Cameron Creek. From a total of 20 specimens of *L. eastoni* in this collection, the holotype and eight paratypes have been selected.

*Occurrence and number of Wyoming specimens.*—Horseshoe Shale Member: collections 1 (4), Carbon County; 53 (35), 54 (5), Johnson County. Ranchester Limestone Member: collections ?84 (1), ?100 (1), Lincoln County; ?130 (1), ?131 (1), 136 (14), 141 (1), Teton County; 133 (2), 134 (8), Sublette County.

*Linoproductus planiventralis* Hoare

Plate 5, figures 20-25

*Linoproductus planiventralis* Hoare, 1960, p. 228, pl. 32, figs. 1-3; 1961, p. 66, 67, pl. 7, figs. 16, 17, pl. 8, figs. 7-9; Sturgeon and Hoare, 1968, p. 50, pl. 16, figs. 22, 23, pl. 17, fig. 13.

*Diagnosis.*—Medium-sized *Linoproductus* having small umbo and fairly long trail, ornamented by 10 to 16 costae and costellae in space of 1 cm; two nearly parallel spine rows along hinge, equal in prominence; spines few over anterior slope. Brachial valve shallowly concave over visceral disc.

*Description.*—Pedicel valve subquadrate in outline, greatest width at or slightly anterior to hinge; curvature in side profile decreasing fairly rapidly from umbo; trail gently convex to straight. In posterior profile, valve rather low arched over visceral disc, becoming even more depressed over its anterior margin; flanks moderately steep, nearly straight. Ears moderately large, gently arched. Umbonal region fairly short, beak incurved; umbonal slopes inclined, rounding gradually into ears, diverging at angle of about 105° at umbo.

Pedicel valve ornamented by rounded costae and some costellae, increasing by intercalation, separated by rounded grooves whose width approximates that of costae. Wrinkles present on umbonal

slopes and flanks near ears, typical of *Linoproductus*. Spines occur in double row along hinge, increasingly gradually in size toward cardinal extremities, and a few large spines scattered over shell, generally in median part; spine bases reaching 2.5 mm in length 1.5 mm in width and some spines slightly exceeding 1 mm in diameter near base; costae tend to converge anterior to spine bases.

Interior of pedicle valve poorly known. Adductor muscle-scar area indistinct, narrow, beginning about 7 mm in front of umbo. Diductor muscle-scar areas at either side, rather strongly ridged longitudinally, occupying areas 7–15 mm in front of umbo.

Brachial valve moderately deep but shallowly concave over visceral disc, generally showing faint broad fold near anterior edge of visceral disc; ears bordered anteriorly by slightly diagonal ridges. Faint wrinkles and rugae present, strongest at side and near ears. Ornamentation of bifurcating costae and costellae equal in strength and spacing to those on pedicle valve.

Interior of brachial valve with short cardinal process, bilobate above; details of myophore not seen. Cardinal ridges fairly straight, paralleling hinge lines, then curving forward short distance, separating visceral disc from ears, and dying out. Median septum continuing forward from cardinal process, weakly differentiated from convex posterior platform. Other details not preserved.

Most complete pedicle valve (USNM 167715) has following dimensions (in mm): length 33, length along arch 57, maximum width 40 (twice the half width), depth 17. Brachial valve (USNM 167717) measures: length 26, length along arch 28, maximum width 33, width of hinge 32 (twice the half width), depth 7.

*Discussion.*—This species was originally described by Hoare (1960, p. 228; 1961, p. 66) from the Seville Limestone of Des Moinesian age in southwest Missouri. More recently Sturgeon and Hoare (1968, p. 50) have recognized it as the common *Linoproductus* in the Pottsville Group in Ohio. Specimens from the Amsden Formation from beds of later Morrowan and early Atokan age in the Rawlins hills, from which the foregoing description was made, agreed rather closely with the Pottsville examples and fall well within the limits of this species as described by Sturgeon and Hoare.

*Linoproductus planiventralis* is clearly distinct from *L. eastoni* n. sp. differing in its subquadrate outline, shorter beak and trail, absence of any tendency to form a fold on the trail in the pedicle

valve, much less concave visceral disc in the brachial valve with its broad weak fold developed on the anterior part, relatively wider hinge, and the presence of costae, rather than costellae, as the major element of longitudinal ornamentation on both valves. In *L. eastoni* the spine row near the posterior margin in the pedicle valve diverges at an angle of 10° and the cardinal ridges within the brachial valve diverge at angles of 20° to the hinge line; in *L. planiventralis* both are parallel to the hinge line. Finally, the spines on the slope of the pedicle valve in *L. planiventralis* are not as thick nor as numerous as in *L. eastoni*.

*Figured specimens.*—USNM 167715–167718.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 2 (3), 3 (19), 74 (1), 5 (1). Ranchester Limestone Member: collection 6 (6), Carbon County.

Order RHYNCHONELLIDA  
Superfamily RHYNCHONELLACEA  
Family not certain  
Genus PUGNOIDES Weller, 1910  
*Pugnoides quinqueplecis* Easton  
Plate 7, figures 6–30

*Pugnoides ottumwa* (White). Branson and Greger, 1918, p. 319, pl. 18, figs. 12–14.

*Selenella? walteri* C. Branson, 1937 [part], p. 657, pl. 89, fig. 22 [not fig. 21].

*Wellerella osagensis* (Swallow). Burk, 1954, p. 14, pl. 1, figs. 23–25.

*Pugnoides quinqueplecis* Easton, 1962, p. 67, pl. 9, figs. 10, 11.

*Diagnosis.*—*Pugnoides* having four or five, rarely three, rather narrow subrounded to subangular plications on fold, separated by shallow grooves.

*Description.*—Shell rhynchonelliform, moderately small, with prominent fold and sulcus. Both valves ornamented anteriorly by 10 to 15 moderately shallow plications, 2 to 4 occupying sulcus and 3 to 5 on fold, obsolete to absent on posterior part of shell, crossed by several growth lamellae on anterior part of shell; no visible microsculpture.

Pedicle valve suboval to subpentagonal, rarely subtriangular in outline, not very deep, prominently rostrate, terminating posteriorly in slightly curved umbo. Umbonal slopes converging at angle of 100° and flattened so as to form false interarea; umbonal slopes meeting main part of valve at angulation along posterolateral extremities. Interior of pedicle valve having pair of moderately short dental plates each supporting prominent hinge tooth at either side of delthyrial cavity.

Brachial valve convex, usually deeper than pedicle valve, transversely suboval in outline; greatest convexity near middle. Surface slopes steeply to postero-



lateral margins and somewhat less steeply to antero-lateral margins. Posterior part of valve rather flattened medially; fold restricted to anterior part of valve, rather elevated at anterior margin.

Interior of brachial valve having shallow median septum occupying posterior two-fifths of valve and dividing in two posteriorly to form septalium, each side of which ends against one of two crural bases. Crura moderately long, diverging slightly anteriorly and curving toward pedicle valve. Inner hinge plates likewise moderately long and perforated by an elongate oval hole; outer hinge plates shorter. Muscle scars in area of median septum flabellate.

*Dimensions (in mm).—*

|                                      | <sup>1</sup> USNM<br>167727 | USNM<br>167725 | USNM<br>167728 | USNM<br>167726 | USNM<br>167729 |
|--------------------------------------|-----------------------------|----------------|----------------|----------------|----------------|
| Length ----                          | 13.0                        | 11.5           | 11.0           | 10.8           | 10.5           |
| Width -----                          | 12.1                        | 11.1           | 12.7           | 10.6           | 10.6           |
| Thickness -                          | 7.0                         | 7.1            | 6.0            | 6.5            | 5.5            |
| Number of<br>plicae on<br>fold ----- | 3                           | 5              | 5              | 3              | 4              |

<sup>1</sup> All specimens from collection 38.

*Discussion.*—This variable species is rather common in the *Composita poposiensis* Subzone in central and north-central Wyoming where it seems to be limited to that zone. Specimens are completely replaced by chert except at one collection (69) just across the border in Montana, which provided sili-cified shells showing internal structures.

Two paratypes of *Selenella? walteri* Branson, one of which was figured by Branson, probably represent the early neanic stage of this species. Both of these tiny shells (UM 6582, 6594) are smooth and subtriangular; one of them has the slight depression in the midposterior part of the brachial valve typical in rhynchonellids. The holotype of *S.? walteri* is more elongate and more rounded anteriorly and is not recognized as a rhynchonellid.

The average specimen of *P. quinqueplecis* has four plicae on the fold, but specimens having three or five on the fold are also common. Of 31 specimens collected at locality 38, 7, or 22 percent, have 3 plicae on the fold, 16, or 52 percent, have 4 plicae, and 8, or 26 percent, have 5 plicae. This constitutes a considerable preponderance (78 percent) of individuals having four or five plicae on the fold.

*P. quinqueplecis* is rather closely related to *P. ottumwa* (White) to which species Branson and Greger (1918, p. 319) originally referred the Wyoming shells. Specimens of *P. ottumwa* from the "Pella Beds" of Iowa have deeper more angular plicae along the anterior margin, and the average number on the fold is less. Of 280 specimens from USGS

locality 5793-PC, about three-fourths of a mile south-southwest of Pella, Iowa, 21, or 7½ percent, have 2 plicae on the fold, 210, or 75 percent, have 3 plicae, 45, or 16 percent, have 4 plicae, and only 4, or 1½ percent, have 5 plicae. By far the most (82½ percent), have less than four plicae. No specimens of *P. quinqueplecis* have been found having only two plicae on the fold.

Included in *P. quinqueplecis* are specimens identified by Burk (1954, p. 14, pl. 1, figs. 23-25) as *Wellerella osagensis* (Swallow) from Cherry Creek, South Pass, and Horse Creek. All of them are from the *Composita poposiensis* Subzone and are conspecific with the specimens identified earlier by Branson and Greger as *Pugnoides ottumwa*. Also included in *P. quinqueplecis* are specimens from Cherry Creek listed by Shaw and Bell (1955, fig. 1) as *Wellerella* sp. indet. *Wellerella osagensis?*, and those from Cherry Creek, South Pass, and Horse Creek listed by Shaw (1955, p. 62, 63) as *Wellerella* n. sp. A and *Wellerella* n. sp. B. All these specimens have been reexamined by the writer and should be referred to Easton's species.

*Figured specimens.*—USNM 167720-167726.

*Additional measured specimens.*—USNM 167727-167729.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections ?21 (2), 26a (5), 26b (7), 32 (6), 34 (3), 35 (31), 36a (2), 36b (51), 36e (10), 38 (34), ?39 (3), 43 (4), B (12), C (14), D (2), Fremont County, Wyo.; 69 (100+), Carbon County, Mont. Ranchester Limestone Member: collection 82 (1), Lincoln County, Wyo.

Superfamily STENOSCISMATACEA  
Family STENOSCISMATIDAE  
Genus COLEDIUM Grant, 1965

*Coledium fragum* n. sp.

Plate 7, figures 1-5, 32-36

*Diagnosis.*—*Coledium* having fairly narrow sub-triangular shell with narrow fold bearing two closely spaced costae; one weak costa in sulcus and as many as two on each flank.

*Description.*—Shell rather small for genus, subtriangular in outline, greatest width about two-thirds of distance anterior to beak; longer than wide, wider than thick, moderately to strongly biconvex; anterior profile commonly subtrapezoidal. Commissure uniplicate; fold narrow and moderately high but elevated above flanks only at anterior end, crest nearly flat; sulcus narrow and fairly shallow, beginning 5 to 7 mm in front of beak, extending forward as tongue into fold; juveniles less than 5 mm long have margin straight or slightly indented. No



sign of stolidium along anterior margin. Costae rather weak, beginning 4 to 6 mm in front of beaks, one broad shallow costa in sulcus, on some specimens appearing before sulcus, and generally two weak ones at either side; two on fold closely spaced, one or two at either side. Valves on mature individuals meeting at anterior margin at angles ranging from acute to obtuse.

Pedicle valve strongly convex posteriorly in side profile, becoming gently convex anteriorly, moderately convex transversely. Umbo medium sized, umbonal angle about 105°, beak erect to slightly incurved ridges obtusely subangular on some specimens, subrounded on others; slitlike foramen appears to penetrate apex of beak on best preserved specimens. Delthyrium triangular, open, largely filled by beak of brachial valve.

Pedicle valve interior having dental plates forming boat-shaped spondylium sessile on floor of valve for slightly less than 1 mm, then elevated on medium septum that extends about one-third of way forward across valve.

Brachial valve strongly convex, both longitudinally and transversely, less convex over middle part; greatest convexity in longitudinal profile a little posterior to middle of valve; beak profile a little posterior to middle of valve; beak forming obtuse angle, its apex within pedicle valve.

*Dimensions (in mm).—*

|                    | USNM<br>167731 | USNM<br>167730 | USNM<br>167733 | USNM<br>167732 |
|--------------------|----------------|----------------|----------------|----------------|
| Length -----       | 9.0            | 6.7            | 6.2            | 4.3            |
| Maximum width ---- | 8.8            | 6.2            | 6.0            | 4.0            |
| Thickness -----    | 5.6            | 3.9            | 4.3            | 2.2            |

*Discussion.*—This species is based on seven fairly complete specimens plus a brachial and two pedicle valves in a collection from the Moffat Trail Limestone Member. Its distinguishing characters are the longer-than-wide subtriangular shell, the narrow fold ornamented by two closely spaced short costae, and the fairly weak but distinct costae.

*Coledium obesum* (Clark) from the Heath Formation of Montana is more inflated and has a broader fold and indistinct costae. *C. explanatum* (McChesney) is associated with *Diaphragmus cestrionensis* (Worthen) at many Chesterian localities in the American midcontinent, as is *C. fragum* in this Moffat Trail collection; *C. explanatum* differs in having stronger costae and a somewhat wider fold bearing two costae that are separated by an intercostal groove equally as wide as the costae.

Of the North American colediums, the one most similar in shape and ornamentation to *C. fragum* is *C. rhomboidale* (Hall and Clarke) from the Mid-

dle Devonian of Indiana. *C. rhomboidale* differs mainly in its costation, having two or three costae on the fold and as many as three on each flank; in *C. fragum* the number is constantly two on the fold and not more than two on each flank.

*Types.*—Holotype, USNM 167730; paratypes, 167731–167734 (9 specimens).

*Occurrence and number of specimens.*—Moffat Trail Limestone Member: collection 93 (10) Lincoln County.

Order SPIRIFERIDA  
Suborder ATHYRIDIDINA  
Superfamily ATHYRIDACEA McCoy  
Family ATHYRIDIDAE McCoy  
Genus CLEIOTHYRIDINA Buckman, 1906  
*Cleiothyridina atrypoides saginata* n. subsp.

Plate 7, figures 54–57

*Diagnosis.*—*Cleiothyridina* resembling *C. atrypoides* Girty, but differing in having more tumid shell with subquadrate outline, more strongly convex pedicle valve, and lesser deflection of line of commissure by fold and sulcus.

*Descriptions.*—Shell moderately small, suborbicular, valves of subequal depth. Pedicle valve atrypiform, tumid, rounded subquadrate in outline, greatest width very slightly posterior to middle; strongly convex in both side and posterior profiles; greatest convexity near umbo, gradually decreasing toward anterior margin. Umbo low, umbonal slopes diverging at angle of approximately 105°. Sulcus beginning almost imperceptibly near midlength and continuing shallowly and poorly delimited to anterior margin where line of commissure exhibits broad shallow rounded deflection. Delthyrium open, filled by beak of brachial valve.

Brachial valve similar in depth and convexity to pedicle valve; greatest convexity in posterior profile at umbo, but in side profile appearing almost evenly rounded. Fold poorly delimited, corresponding to sulcus of pedicle valve.

Surface sculpture on both valves consisting of concentric grooves and closely spaced fine lamellae, particularly visible and crowded on anterior half of shell; locally fine short spines are visible fringing lamellae. Internal characters of both valves not known.

Dimensions of figured specimen (in mm): length 15.2, width 15.7, and thickness (both valves) 11.0.

*Discussion.*—The unique specimen upon which the foregoing description is based was collected in the Washakie Range. It differs from previously described North American cleiothyridinas in the great convexity of the pedicle valve, which is equal to that of the almost hemispherical brachial valve.

This shell is closely allied to *C. atrypoides* Girty from the Fayetteville Shale of Arkansas and Oklahoma, from which it differs in the particulars given in the diagnosis. It is regarded as representing a western subspecies of *C. atrypoides*. Its age is probably slightly younger than that of Girty's original material of *C. atrypoides*—middle Chesterian as opposed to later early Chesterian.

*C. atrypoides* Girty (1910, p. 223) was described originally as a variety of *C. sublamellosa* (Hall), from which it differs in having a more convex, deeper pedicle valve and a deeper sulcus that causes a marked deflection in the line of commissure. Easton (1962, p. 75, pl. 10, figs. 23a-c) selected and designated a "holotype" (lectotype) from among Girty's specimens and figured it. He considered *C. atrypoides* a valid species and assigned to it several specimens from the Heath Formation of central Montana. Girty's unfigured syntypes of *C. atrypoides* include several hundred specimens from approximately 20 localities in Arkansas and Oklahoma. Easton's designation of the lectotype (USNM 118718, from USGS loc. 3651C) has fixed the type locality of *C. atrypoides*, which is 6 miles airline east of Fayetteville, Ark.

*Holotype*.—USNM 168390.

*Occurrence*.—Horseshoe Shale Member: collection 41, Teton County.

*Cleiothyridina hirsuta darwinesis* n. subsp.

Plate 7, figures 31, 38–40, 42–45, 58, 59

*Cleiothyridina* sp. Burk, 1954 [part], p. 13 [not pl. 1, fig. 15].

*Diagnosis*.—Small *Cleiothyridina* of moderate thickness, subpentagonal in outline, having pedicle valve deeper than brachial valve; fold and sulcus subdued but fairly broad; umbo rather short, incurved. Interior of both valves having prominent coarse radial vascular grooves.

*Description*.—Shell atrypiform, subpentagonal, tending toward subcircular in outline, lenticular in cross section; length subequal to width, being either slightly greater or slightly less. Pedicle valve having fairly straight posterior margins that diverge at angle of approximately 115°, strongly rounded lateral margins that curve less strongly anteriorly, and rather straight anterior margin at termination of fold and sulcus; greatest width approximately at middle of valve; appearing rather evenly convex in side profile but less convex near anterior margin; greatest depth just posterior to middle; evenly rounded in posterior profile. Sulcus shallow and rather broad, visible only on anterior third of valve. Line of commissure broadly and shallowly indented

anteriorly; in side view, line appears almost straight, except at anterior end; viewed from posterior end, line of commissure has faint bulge at either side of umbo at expense of brachial valve. Umbo fairly small and incurved; beak erect; apical angle approximately 80°.

Interior of pedicle valve bearing pair of fairly short dental plates within umbonal region; interior surface marked by straight, rather coarse, relatively prominent vascular grooves, 14 on holotype, that extend to margin and appear as ridges on internal mold.

Brachial valve similar in outline to pedicle valve but shorter and slightly shallower, about four-fifths as deep as pedicle valve; greatest depth occurring one-quarter to one-third distance from beak to anterior two-fifths of valve; on some specimens fold bears faint medial longitudinal depression. Surface sculpture decorticated in type lot. Interior marked by radiating vascular grooves of which 20 occur on figured specimen, appearing to increase by intercalation. Shallow sharp short medial groove extending forward from beak; cardinal plate not seen.

*Dimensions (in mm).*—

|                  | USNM<br><sup>1</sup> 163721 | USNM<br><sup>2</sup> 168391 | USNM<br><sup>2</sup> 168392 | USNM<br><sup>2</sup> 168393 | UW<br><sup>3</sup> IT-230 |
|------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|---------------------------|
| Length -----     | 13.2                        | 12.4                        | 10.5                        | 9.6                         | 7.5                       |
| Maximum width -- | 12.8                        | 12.6                        | 10.5                        | 9.3                         | 8.0                       |
| Thickness -----  | 7.7                         | 7.4                         | 6.0                         | 5.5                         | 4.0                       |

<sup>1</sup> USNM 168391–168393 are from collection 137.

<sup>2</sup> USNM 163712 is from collection 27.

<sup>3</sup> IT-230 is from collection 43.

*Discussion*.—The description above is based on six specimens collected by Blackwelder from the Darwin Peak section. Several of these are shallowly excavated anteriorly at either side of the line of commissure, which is marked by a narrow ridge. Such an arrangement normally indicates that the shell, which is missing from these specimens, was fairly thick. That this was so is demonstrated by a USGS specimen collected by C. C. Branson at Cherry Creek (pl. 7, figs. 58, 59). This retains some of the original shell material and shows the closely crowded surface lamellae typical of *Cleiothyridina*; these, however, lack most of the spines. The dimensions of this shell (USNM 163712) are given in the table above. Three U.S. National Museum specimens from Amsden Hill, collected by C. C. Branson and Hackett are included here, as well as two University of Missouri specimens collected by C. C. Branson at Little Popo Agie River.

Also referred to this species and included in the table of dimensions is a small specimen collected by C. A. Biggs at Horse Creek, in the collection of the University of Wyoming. It was included by Burk

(1954, p. 13) among 15 specimens he described as *Cleiothyridina* sp. All except this specimen are young compositas, including the one Burk figured.

Finally, a large silicified specimen collected by I. A. Keyte in Enterprise Ditch near Lander is referred to this species with some question. It measures 15 mm long (estimated because the beak is missing), 15.5 mm wide, and 8.3 mm thick and is figured on plate 7, figures 46–49. Although its shape is reasonably close to *C. hirsuta darwinensis*, the surface is relatively smooth, having neither the spinose lamellae typical of the exterior of *Cleiothyridina* nor the vascular grooves typical of the interior of this species, and its sulcus is fairly prominent at the anterior margin. These differences can be explained, however, as caused by peculiarities of preservation and by its relatively large size and therefore fully mature development.

*Comparisons and affinities.*—*Cleiothyridina hirsuta darwinensis* differs from typical *C. sublamellosa* (Hall), which is somewhat similar in outline, principally in having the pedicle valve as deep as or slightly deeper than the brachial, instead of having the brachial deeper, as in Hall's species.

The valves of *C. atrypoides* Girty are subequal in depth, the pedicle, if differing, generally being shallower. This fossil is thicker than *C. hirsuta darwinensis* and has a deeper and more prominent sulcus.

*C. hirsuta* (Hall) also has the pedicle valve approximately equal in depth to the brachial valve. Besides having the pedicle the deeper of the two valves, *C. h. darwinensis* differs from *C. hirsuta* (Hall) in having a broader fold and sulcus (where present), slightly less extended umbonal region, and coarse vascular grooves.

*C. orbicularis* (McChesney), the Pennsylvanian species, is closest in size and shape to *C. h. darwinensis*, but one constant difference is the greater development of the bulges of the posterior margin of the pedicle valve at either side of the umbonal region. These bulges are set off from the main part of the valve by an angulation beyond which they extend dorsally a little more than 1 mm. Viewed in side profile, the line of commissure has a distinctly sigmoidal curvature, as opposed to the relatively straight line of commissure in side profile in *C. h. darwinensis*. No coarse vascular grooves have been observed in *C. orbicularis*.

*Types.*—Holotype, USNM 168391; paratypes, 163712, 168392–168394, 168451, UM 6623, UW IT-230.

*Figured specimen.*—(?) USNM 168452.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 26b (3), 27 (1), 36a (2), 36d (2), 43 (1), 44 (2), ?A (1), Fremont County; 137 (6), Teton County.

*Cleiothyridina* aff. *C. elegans* Girty

Plate 7, figures 41, 50–53

*Cleiothyridina hirsuta* (Hall). Branson and Greger, 1918, p. 320, pl. 19, figs. 14.

Two specimens from Cherry Creek are related to Girty's species from the Fayetteville Shale of Arkansas. The first, in the University of Missouri collection, was figured by Branson and Greger as the Meramec species *C. hirsuta* (Hall), which it resembles in having the pedicle valve equally as deep as or slightly deeper than the brachial valve. Comparison with specimens of *C. hirsuta* from the Salem Limestone at Spurgeon Hill, Ind., shows that the Amsden shell is more suboval in shape transversely, having a slightly shorter umbo, and the postero-lateral margins forming an obtuse angle. A narrow shallow median sulcus depresses the anterior part of the pedicle valve, but a corresponding fold cannot be seen on the brachial valve. The internal mold of the pedicle valve is marked, near the anterior margin, by faint radial lirae of which seven or eight occur in the space of 2 mm. If these are vascular markings, they are much finer than those on *C. darwinensis* n. sp. They might, however, be impressions of the radially lirate structure observed commonly in shells of athyridaceans, including some species of *Cleiothyridina*.

The second specimen, in the collection of the University of Wyoming, was listed by Shaw and Bell (1955, fig. 1) in an annotated columnar section of the lower part of the Amsden Formation at Cherry Creek as "*Torynifer* cf. *T. setigera*." It retains part of the outer shell of the pedicle valve, which preserves the fine concentric lamellae and tiny spine fringes of *Cleiothyridina* and does not have the coarse spine rows of *Torynifer*. The anterior part of this specimen is broken, which requires the slight addition by estimation of its length given below.

The dimensions of the two specimens (UM 2654 and A 205, respectively) are as follows: length 11.9 and 13 mm (estimated), width 12.4 and 14.4 mm, thickness (both valves) 6.0 and 7.0 mm.

These shells appear to be intermediate between *C. hirsuta* (Hall) and *C. elegans* (Girty). They are more transverse than typical *C. h. darwinensis* and lack the prominent vascular grooves seen in that form.

*Figured specimen.*—UM 2654.

*Mentioned specimen.*—UW A205.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 29 (1), 36a (1), Fremont County.

*Cleiothyridina* aff. *C. sublamellosa* (Hall)

Plate 7, figure 37

This record is based upon one young specimen and four pedicle valves from two localities in the Moffat Trail Limestone Member. The largest specimen measures (in mm) 11.0 long, 13.0 wide, and 3.6 deep; the smallest is 5.6 long, 6.5 wide, and 2.8 deep. The largest is figured and resembles shells from Heath Formation of Montana that were identified by Easton (1962, p. 75, pl. 10, fig. 18) as *Cleiothyridina* aff. *C. sublamellosa* (Hall). It is a little wider in proportion to its length than the Horseshoe Shale Member form, *C. hirsuta darwinensis* but it has approximately the same depth. This lot was identified under this title by G. H. Girty.

*Figured specimen.*—USNM 168453.

*Occurrence and number of specimens.*—Moffat Trail Limestone Member: collections 73 (1), 93 (4), Lincoln County.

*Cleiothyridina* sp. indet.

Poorly preserved specimens from beds of Pennsylvanian (Morrowan) age are recognized as belonging in *Cleiothyridina* but are not identifiable as species. It has been the custom among American Carboniferous paleontologists to refer all Pennsylvanian shells of this genus to one species, *C. orbicularis* (McChesney). Although the size, shape, and what can be seen of the ornamentation of these Amsden shells does not preclude such an assignment, not enough characters are preserved to enable a positive identification.

*Occurrence and number of specimens.*—Horseshoe Shale Member, collections 1 (1), 2 (1), 3 (2), Carbon County. Ranchester Limestone Member, 131 (1), 139 (1), Teton County.

Genus *COMPOSITA* Brown, 1849

*Composita* aff. *C. laevis* Weller

Plate 8, figures 1–5, 43

*Composita laevis* Weller, 1914, p. 491, 492, pl. 82, figs. 14–20.

Specimens of *Composita* in a shaly limestone bed in the lower part of the Amsden section in Hoback Canyon somewhat resemble Weller's species. The shells are small, subcircular to elongate-oval in outline, and because of their shape can easily be mistaken for small terebratuloids such as *Girtyella* and *Cranaena*, except that the shell structure is fibrous and impunctate. Pedicle valves are longer than wide, widest a little anterior to and deepest a little poste-

rior to midlength. The median sulcus is shallow, beginning near midlength or a little farther back on some specimens. The sulcus causes a moderate rounded deflection in the anterior line of commissure, and the anterior outline is nearly flat or faintly emarginate medially. The umbo is strongly curved and the beak erect to incurved.

Brachial valves are low in the region of the beak, shallower overall than pedicle valves; no fold is present on most shells, but some have a very faintly elevated medial anterior area. Some valves steepen along the anterior margin in the manner of terebratuloids. Surface sculpture is smooth on both valves except for fine concentric growth lines; most shells, however, are decorticated.

Internally, the pedicle valve has a pair of fairly strong dental plates posteriorly. Longitudinal vascular grooves of the type common in *Composita* are strongest in the medial parts of the shell and taper anteriorly; Most prominent is a pair of grooves, one at either side of the sulcus. Some brachial valves have a faint medial lira posteriorly that does not reach the height of a true median septum.

*Dimensions (in mm).*—

|               | <i>Pedicle valves</i> |                  | <i>Brachial valve</i> | <i>Both valves</i> |
|---------------|-----------------------|------------------|-----------------------|--------------------|
|               | USNM<br>1 168397      | USNM<br>1 168398 | USNM<br>1 168399      | USNM<br>2 168396   |
| Length -----  | 13.3                  | 10.0             | 9.2                   | 8.7                |
| Width -----   | 12.0                  | 7.7              | 8.8                   | 7.8                |
| Thickness --- | —                     | —                | —                     | 5.7                |
| Depth -----   | 3.7                   | 2.8              | 2.2                   | —                  |

<sup>1</sup> USNM 168397–168399 are from collection 117.

<sup>2</sup> USNM 168396 is from collection 118.

The Wyoming shells differ from Kentucky specimens of *C. laevis* Weller in being a little less slender on the average, having a slightly flatter brachial valve and a shallower emargination or mere flattening anteriorly. Nevertheless, they seem closely related to Weller's species.

These specimens are not conspecific with those described and figured as *C. laevis* by Easton (1962, p. 76, 77, pl. 11, figs. 1a–2b) from the Heath Formation of Montana, herein regarded as immature specimens of *C. subquadrata* (Hall). These young shells that Easton identified as *C. laevis* have been compared with *C. farrelli* Gunnell from the so-called Brazer Limestone, particularly with a possible paratype in the U.S. National Museum collection (USNM 137560), and appear to be conspecific. Our Wyoming specimens of *C. aff. C. laevis* also have been compared with *C. farrelli*; they are not conspecific. Easton included *C. farrelli* in the synonymy of *C. laevis*, which is not correct but applies so far as the Montana specimens are concerned. For the reason stated above, *C. farrelli* actually belongs in the

synonymy of *C. subquadrata*. Hernon (1937, p. 689), who recorded *C. laevis* in the Paradise Formation of Arizona, did not describe and figure the specimens.

*Figured specimens.*—USNM 168396, 168397.

*Additional measured specimens.*—USNM 168398, 168399.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 1 (1) 2 (1), 3 (2), Car- (118), Teton County.

*Composita subquadrata* (Hall)

Plate 8, figures 31–35, 49; plate 9, figures 37–41

*Athyris subquadrata* (Hall), 1858, p. 703, 708, pl. 27, figs. 2a–d, text fig. 118; Whitfield, 1891, p. 585, pl. 14, figs. 1–3; 1893, p. 472, pl. 10, figs. 1–3; Keyes, 1895, p. 92; Weller, 1897, p. 258, pl. 19, fig. 16.

*Athyris subquadrata* Hall? Hall and Whitfield, 1877, p. 271, pl. 5, figs. 19, 20.

*Seminula subquadrata* (Hall). Hall and Clarke, 1893 [part], p. 95; 1894 [part], pl. 35, figs. 13, 15; 1895 [part], p. 95, pl. 84, figs. 30, 31 [not pl. 47, figs. 7–9, 15, 16], Grabau and Shimer, 1909, p. 354; Bassler, 1909, pl. 29, figs. 6–8; Morse, 1911, p. 383, figs. 13a–c.

*Composita subquadrata* (Hall). Weller, 1914, p. 489, 490, pl. 81, figs. 1–15; Girty, 1915b, p. 72, pl. 4, figs. 15–16a; Butts, 1917, p. 116, pl. 28, figs. 1, 2; Weller, 1920, p. 375, pl. 11, figs. 12–14; Butts, 1926, p. 198, pl. 65, figs. 10–12; Croneis, 1930, p. 74, pl. 19, figs. 27–29; Weller, 1931, pl. 44, figs. 4a, b, c; Butts, 1941, p. 241, pl. 30, figs. 16–18; Easton, 1942, pl. 8, figs. 7, 8; Cooper, in Shimer and Shrock, 1944, p. 335, pl. 28, figs. 13–15; Weller and others, 1952, p. 95, pl. 2, figs. 32, 33; Allen and Lester, 1954, p. 89, 105, 111, pl. 23, fig. 5; pl. 27, fig. 4; pl. 28, fig. 33; Grinnell and Andrews, 1964, p. 232.

*Composita subquadrata* (Hall)? Girty, 1920, p. 651, pl. 53, figs. 9, 9a.

*Composita farrelli* Gunnell, 1932, p. 299, pl. 27, figs. 45, 47, 48.

*Composita laevis* Weller. Easton, 1962, p. 76, 77, pl. 11, figs. 1a–2b.

*Composita ozarkana* Mather. Easton, 1962, p. 77, pl. 11, figs. 5a–7b.

*Composita sulcata* Weller. Easton, 1962, [part], p. 77, 78, pl. 11, figs. 8a–9b.

*Description.*—Medium-sized *Composita*, subquadrate in outline owing to approximately equal length and width, occurrence of greatest width approximately at midlength, divergence of posterior margins at about 90°, and slight extension of fold and sulcus beyond curve of anterior margin. Sulcus in pedicle valve beginning about 6 or 7 mm in front of beak and continuing rather shallowly to anterior margin, where linguaform projection of anterior margin extends into fold, causing moderate to deep rounded deflection of anterior line of commissure. Moderate-sized Amsden specimen is 20.5 mm long, 20 mm wide, and 11.5 mm thick.

*Discussion.*—This species occurs in the Amsden Formation only in western Wyoming where it has been recognized in the Horseshoe Shale and Moffat Trail Limestone Members. Specimens illustrated on plates 8 and 9 are from a locality in the Washakie Range.

*C. subquadrata* is a ubiquitous Chesterian species found in many areas in the United States. It seems to grade on the one hand into *C. trinuclea* (Hall) and on the other into *C. sulcata* Weller. When these taxa, however, are viewed from the standpoint of their being populations having overlapping variants, their separate entity is rather easily discerned because most of the typical specimens can be readily distinguished.

The subquadrate outline of this species is most apparent when the shell is viewed after having been rotated 45° from its median axis along the plane of commissure.

*C. subquadrata* is very common in the Heath Shale of Montana but, as pointed out in the discussion of *C. aff. C. laevis*, the shells were described by Easton under several other names. The lot of specimens (USNM 14232) from the Oquirrh Mountains, Utah, collected by the 40th Parallel Survey in rocks of Late Mississippian age, described and figured by Hall and Whitfield (1877) as "*Athyris subquadrata* Hall?," and by Girty (1927) as "*Composita subquadrata* (Hall)?" have been reexamined and found to be conspecific with the shells described here.

*Figured specimens.*—USNM 168429–168432.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collection 41 (46), Teton County. Moffat Trail Limestone Member: collections 76 (1), 93 (2), Lincoln County; 145 (12), Teton County.

*Composita sigma* n. sp.

Plate 8, figures 21–30, 36–39; plate 9, figures 21–30.

?*Martinia* n. sp. Branson and Greger, 1918, p. 319, pl. 19, figs. 17, 18.

*Diagnosis.*—Small to medium-sized *Composita*, subcircular to elongate oval in outline; sulcus prominent only on middle of anterior one-third of pedicle valve. Fold tending to flare slightly at anterior margin, delimited by pair of faint sulci on anterior one-fifth of brachial valve.

*Description.*—Pedicel valve somewhat variable in shape, having length equal to, less than, or slightly greater than width; greatest width at or near middle; greatest thickness posterior to middle; convexity moderate, in side profile having greatest curvature at umbo and gradually decreasing anteriorly; in posterior profile moderately to gently

arched, flatter over sulcus. Sulcus narrow and shallow in posterior half of valve, not developed at all on some specimens, more prominent on anterior one-third of valve where it is broadly V-shaped, reaching not quite one-half width of valve at anterior margin, slightly produced in linguaform tongue extending a little beyond curvature of margin in some specimens, producing moderately deep rounded deflection of line of commissure anteriorly. Umbo rather low, curving strongly dorsad; beak incurved; posterior margins diverging at angles ranging from 90° to 110°. Surface smooth except for several faint concentric grooves on shell and fairly strong lamellae near anterior margin.

Brachial valve about as convex as pedicle valve

*Dimensions (in mm).—*

|                 | USNM<br><sup>1</sup> 168416 | USNM<br><sup>1</sup> 168417 | YPM<br><sup>2</sup> 20109b | YPM<br><sup>2</sup> 20109c | YPM<br><sup>2</sup> 20109d | USNM<br><sup>1</sup> 168418 | USNM<br><sup>1</sup> 168419 | USNM<br><sup>2</sup> 168411 | USNM<br><sup>2</sup> 168412 | YPM<br><sup>2</sup> 20109a | USNM<br><sup>2</sup> 168413 | USNM<br><sup>2</sup> 168414 |
|-----------------|-----------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|
| Length -----    | 17.5                        | 15.5                        | 15.5                       | 15.0                       | 14.8                       | 14.7                        | 14.5                        | 14.2                        | 13.3                        | 12.2                       | 11.9                        | 10.9                        |
| Width -----     | 16.2                        | 15.0                        | 14.1                       | 14.8                       | 12.5                       | 13.3                        | 15.0                        | 14.4                        | 11.7                        | 12.0                       | 12.0                        | 10.4                        |
| Thickness ----- | 11.4                        | 10.5                        | 8.4                        | 9.1                        | 9.5                        | 9.5                         | 8.5                         | 8.6                         | 7.8                         | 7.0                        | 7.3                         | 6.6                         |

<sup>1</sup> USNM 168416-168419 are from Livingston Ranch (colln. 45).

<sup>2</sup> USNM 168411-168414 and YPM 20109a-d are from Wiggins Fork (collns. 47, 48).

*Discussion.*—This species is based upon specimens from Wiggins Fork in the Washakie Range, supplemented by additional material from Livingston Ranch in the same range. Designated paratypes are in the U.S. National Museum and Yale University Peabody Museum collections. *C. sigma* occurs also at Cherry Creek and other localities in the Wind River Range, where it is restricted to the lower fossiliferous beds of the Horseshoe Shale Member, associated with *Anthracospirifer welleri welleri* (Branson and Greger).

*C. sigma* is recognized by its subcircular to elongate suboval outline, by relative suppression of the median sulcus and lack of lateral sulci of flat flanks in the pedicle valve, and by a rather weak short fold that tends to flare slightly in the brachial valve.

The general shape of this species resembles that of *C. poposiensis* n. sp., which seems to be a severally sulcate and somewhat subangular modification of it. The apparent stratigraphic relations in the vicinity of Cherry Creek point to *C. sigma* as the progenitor of *C. poposiensis*.

*C. sigma* has been identified also in western Wyoming in Upper Mississippian beds, including those of latest Mississippian age (Zone 19 of Mamet); *C. poposiensis* is not found in this part of Wyoming. The late forms of *C. sigma* in this part of the State lack the slight flare of the fold normally found in Fremont County specimens and the median sulcus begins nearer to the umbo on pedicle valves. These are characters also found in *C. poposiensis*, indicat-

and similar in outline; in side profile having greatest curvature near beak, greatest depth one-third of way forward from beak, and becoming slightly concave near anterior margin on most specimens so that profile from beak to tip of fold follows sigmoidal curve; moderately arched in posterior profile, having greatest curvature over middle of valve, becoming more gently on flanks. Line of commissure depressed slightly at either side of fold. Ornamentation same as on pedicle valve.

Internally, pair of short dental plates present in pedicle valve; umbonal cavity rather shallow owing to incurving of beak. Brachial valve has narrow medial lira dividing muscle field. Hinge plate not seen.

ing that the western Wyoming forms underwent part of the modifications that derived *C. poposiensis* from *C. sigma*. However, as no highly sulcate forms are present in the western Wyoming beds, these slightly different shells are regarded merely as variants of *C. sigma*.

Included tentatively in *C. sigma* is a unique shell from the Horseshoe Shale Member at Cherry Creek which was described as a *Martinia* by Branson and Greger (1918), but does not have the shape of that genus. The shell (UM 2652) is figured on plate 8, figures 26-30. It is elongate oval in outline, shallowly sulcate, the greatest width approximately at the middle, and measures (in mm): length 8.9, width 6.8, and thickness 4.5 (allowing for a small part that someone has ground off). It appears to be a narrow *Composita*, differing from typical specimens of the genus only in that the beak of the brachial valve is rather straight and does not curve into and occupy the delthyrium of the pedicle valve. It has dental plates in the pedicle valve and no median septum in the brachial valve. It is referred to *C. sigma* with question as an aberrant specimen of this species.

*Comparisons and affinities.*—The wider shells of *C. sigma*, having a subcircular outline, somewhat resemble shells of *C. ovata* Mather, a common and long-ranging Pennsylvanian species. *C. ovata*, however, is a larger species having a broad shallow medial sulcus and fold that make a rather wide and shallow deflection in the anterior line of commissure.

In *C. sigma* this deflection is deeper and narrower and flanked by shallow deflections in the opposite direction which are caused by the short sulci that flank the fold in the brachial valve.

*Types*.—Holotype, USNM 168411; paratypes, USNM 168412–168421, 168454; YPM 5154b, 20109a–d.

*Figured specimen*.—UM 2652.

*Occurrence and number of specimens*.—Horse-shoe Shale Member: collections ?22 (3), 26b (78), 27 (8), 28 (1), ?29 (1), 36a (116), 36e (1), 39 (33), 44 (17), 45 (159), 47 (26), 48 (70), B (8), E (22), Fremont County; 137 (15), 149 (40), 152 (5), 153 (8), 154 (25), ?156 (1), ?159 (2), Teton County. Ranchester Limestone Member: collections 82 (45), 97 (5), Lincoln County; 146 (12), 160 (1), Teton County.

*Composita poposiensis* n. sp.

Plate 8, figures 6–20; plate 9, figures 1–15, 31–36

*Composita trinuclea* (Hall). Branson and Greger, 1918 p. 319, 320, pl. 18, figs. 1–4.

*Composita subtilita* var. *subtilita* (Hall). Burk, 1954 [part], p. 12, pl. 1, figs. 5–7, 12.

*Composita subtilita* var. *ovata* Mather. Burk, 1954 [part], p. 12, 13, pl. 1, figs. 2, 4 [not figs. 3, 11].

*Composita subtilita* var. *trinuclea* (Hall). Burk, 1954, p. 13, pl. 1, figs. 8–10.

*Cleiothyridina* sp. Burk, 1954 [part], p. 13, pl. 1, fig. 15.

*Diagnosis*.—Small to medium-size *Composita*, typically five- to seven-sided in outline, but varying toward elongate suboval or subcircular; greatest width anterior to and greatest thickness posterior to midlength. Anterior part of pedicle valve having deep median sulcus and two shallower lateral sulci separated by narrowly rounded ridges; corresponding part of brachial valve having broadly rounded fold set off by broad shallow sulci.

*Description*.—Pedicle valve variable in shape and outline, length generally greater than width,

but rarely less than width; posterior margins diverging at angles ranging roughly from 90° to 110°; lateral margins nearly straight to gently rounded, subparallel or diverging slightly so that greatest width is a little anterior to midlength; anterior margin rounded, in some specimens divided into three parts by protruding fold and sulcus; boundaries between posterior and lateral margins and lateral and anterior margins more strongly rounded, approaching subangular in some specimens. In side profile, greatest convexity near umbo, decreasing toward anterior margin; in posterior profile rather flat over middle of arch, with sloping straight or gently convex flanks. Median sulcus beginning normally 3–5 mm in front of beak, in some specimens within 1 mm of beak, and extending to anterior margin where it occupies nearly three-fifths of maximum width of shell, bounded by strongly rounded diverging ridges; shallower round-bottomed sulcus commonly present on either flank; median sulcus extending forward and causing strong rounded deflection in line of commissure, two gentle deflections marking position of lateral sulci. Surface sculpture consisting of concentric grooves, lirae, and lamellae of growth, crossed by very faint tiny radial striae.

Interior of pedicle valve having pair of dental plates within umbonal region; shell thickened and pitted just in front of dental plates; heart-shaped muscle scar occupies depressed area in middle.

Brachial valve elongate, suboval to subcircular, shallower and less convex in side profile than pedicle valve, but equally convex in posterior profile. Fold restricted to anterior one-third of valve, flanked by pair of broad shallow sulci terminating in fairly prominent rounded deflections of line of commissure. Sculpture similar to that on pedicle valve. Interior of brachial valve having cardinal plate concave on ventral side and indented apically by subconical pit.

*Dimensions (in mm)*.—

|                 | USNM<br>1 168400 | USNM<br>2 168406 | USNM<br>3 168403 | USNM<br>4 168401 | USNM<br>5 168404 | USNM<br>6 168407 | USNM<br>7 168405 | USNM<br>8 168408 |
|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Length -----    | 19.7             | 16.8             | 16.3             | 14.7             | 14.0             | 12.4             | 10.9             | 10.5             |
| Width -----     | 16.4             | 17.2             | 13.7             | 14.7             | 13.7             | 11.5             | 10.5             | 10.2             |
| Thickness ----- | 11.5             | 10.0             | 9.8              | 9.3              | 7.8              | 7.8              | 6.2              | 6.8              |

<sup>1</sup> USNM 168400 and 168401 are from Amsden Hill.

<sup>2</sup> USNM 168403–168406 are from Enterprise Ditch.

<sup>3</sup> USNM 168407 and 168408 are from the Little Popo Agie River (colln. 38).

*Discussion*.—*Composita poposiensis* n. sp. is erected principally for Wyoming shells identified by previous workers as "*Composita trinuclea* (Hall)" or "*C. subtilita* var. *trinuclea* (Hall)." Also included in the new species are some of the specimens identified by Burk (1954) as *C. subtilita* var. *subtilita* (Hall), *C. subtilita* var. *ovata* Mather, and *Cleiothy-*

*ridina* sp. These are all regarded as component parts of a single, somewhat variable population. The sulcate *trinuclea*-like form is by far the most abundant. Among 237 specimens in collection 38, 115 (48½ percent) are moderately sulcate; 28 (12 percent) deeply sulcate; 45 (19 percent) more rounded and with less developed lateral sulci, including both



*ovata*-like and *subtilita*-like forms; and 49 (20½ percent) are somewhat immature specimens, including many that resemble those referred by Burk to *Cleiothyridina* sp. Of the adult shells, 76 percent belong to the *trinuclea*-like form.

The holotype is a well-preserved specimen collected by I. A. Keyte at Amsden Hill. Paratypes have been designated from this locality and from Enterprise Ditch, Little Popo Agie River, and Cherry Creek. Included among the paratypes are specimens figured by Branson and Greger (1918) and by Burk (1954). Only the one figured by Branson and Greger on their plate 18, figures 1 and 4, is so designated; the other, an extreme *subtilita*-like form (figures 2 and 3 on the same plate) is missing and has not been available for study.

*C. poposiensis* is rather easily distinguished from *C. trinuclea* (Hall) by a constant difference in outline. A well-preserved specimen of *C. trinuclea* (USNM 168422) from the Pella beds of late Meraecian age, 4½ miles south of Pella, Iowa, is figured in this report on plate 9, figures 16–20. In Hall's species the outline of the shell is subtriangular to subrhombic, the posterior margins extending forward from the beak and curving into the lateral margins without a noticeable break as far as the point of greatest width, a little in front of midlength. In typical *C. poposiensis*, the outline, although somewhat rounded, ranges from subpentagonal through subseptagonal, the lateral margins being subparallel or diverging slightly. A noticeable change in direction of gentle subangulation normally marks the boundary between the posterior and lateral margins in this species.

This feature is seen in all but the most extreme *subtilita*-like shells, which are relatively rare, and it raises the question whether these exceptions are correctly included in *C. poposiensis*. The principal evidence available in this regard is incorporated in a bilaterally asymmetrical specimen from the valley of Little Popo Agie Creek figured on plate 9, figures 6–10. The right half of this specimen has an outline showing a slight deflection at the boundary between the posterior and lateral margins; because of this it is *poposiensis*-like in shape. The left half has the posterior margin passing into the lateral margin without a break, as in *C. subtilita*. Mainly because of this specimen the extreme *subtilita*-like forms are here included in *C. poposiensis*. No specimens identical with typical *C. trinuclea* from the American mid-continent have been found at the Wyoming localities.

The typical form of this species, having a trisulcate pedicle valve, is not known outside Fremont

County, and specimens from Horse Creek in the Washakie Range are the only ones known outside the Wind River Range. Nearly all the specimens of *C. poposiensis* are silicified and chert filled, and most, if not all, of these have probably come from the upper zone in this region, which we are calling the *Composita poposiensis* Subzone. The only known occurrence of this species in the *Carlinia amsdeniana* Subzone is a pedicle valve collected in place in sandstone at Cherry Creek (colln. 31) by W. G. Bell, a former student at the University of Wyoming, in the Horseshoe Shale Member, 47–48 feet above the base of the Amsden Formation.

*Types*.—Holotype, USNM 168400; paratypes, USNM 168401–168410 (18 paratypes), UM 2655, UW IT-211, IT-212, IT-215, IT-221, IT-222.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 26a (9), 26b (120), 31 (1), 32 (33), 34 (6), 35 (240), 36a (105), 36e (128), 38 (237), 42 (27), 43 (10), A (21), B (14), Fremont County.

#### *Composita sulcata* Weller

Plate 8, figures 40–42, 44–48, 50–54

*Composita sulcata* Weller, 1914, p. 490, 491, pl. 82, figs. 1–10; Girty, 1927, p. 64, pl. 23, figs. 28–33; Easton, 1962, p. 77, 78, pl. 11, figs. 8a–9b; Grinnell and Andrews, 1964, p. 232.

*Composita subtilita* var. *subtilita* (Hall). Burk, 1954 [part], p. 12 [not pl. 1, figs. 5–7, 12].

*Composita subtilita* var. *ovata* Mather. Burk, 1954 [part], p. 12, 13, pl. 1, figs. 3, 11 [not figs. 2, 4].

*Diagnosis*.—Medium-sized *Composita*, subquadrate to subcircular in outline, having sulcus that begins shallowly and deepens rapidly, causing very prominent rounded medial deflection in line of commissure.

*Description*.—Pedicle valve having length generally slightly greater than width, rarely equal to width; greatest width at or slightly anterior to midlength; greatest thickness posterior to midlength. Posterior margins diverging at angles from 95° to 115°, curving forward slightly to meet well-rounded lateral margins; anterior margin more gently convex. In side profile, curvature of valve rather gentle and even, except at anterior end where prolongation of sulcus curves strongly to fit into fold of brachial valve; in posterior profile rather evenly convex. Sulcus beginning about 5 mm in front of beak, V-shaped, narrow, shallow, and relatively inconspicuous up to length of 10 to 12 mm, then deepening rather rapidly to form strong rounded deflection in line of commissure. Surface of valve smooth, marked only by concentric growth lines and by several

strong lamellae of growth near anterior margin. Umbonal region strongly convex; beak erect to incurved.

Brachial valve transversely oval in outline; in side profile with greatest curvature at beak and lessening to anterior margin, or shallowly concave near anterior margin so that profile along medial line follows sigmoidal curve; in posterior profile narrowly arched medially with fairly straight or gently convex sloping flanks. Fold becomes clearly

delimited only in anterior third of shell. Sculpture as in pedicle valve.

Interior of pedicle valve having pair of fairly short dental plates enclosing moderately deep umbonal cavity; shell pitted in small area at either side. Interior of brachial valve having cardinal plate supported apically by short, fairly broad, low median buttress just in front of which dorsal side of plate is penetrated deeply by long narrow funnel-shaped pit; ventral side of cardinal plate not seen.

*Dimensions (in mm).—*

|                 | USNM<br><sup>1</sup> 168425 | USNM<br><sup>2</sup> 168423 | USNM<br><sup>3</sup> 168427 | USNM<br><sup>2</sup> 168424 | USNM<br><sup>1</sup> 168426 | USNM<br><sup>4</sup> 168428 |
|-----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Length -----    | 20.2                        | 18.1                        | 17.5                        | 15.6                        | 14.2                        | 10.9                        |
| Width -----     | 20.7                        | 19.7                        | 17.6                        | 16.8                        | 14.2                        | 11.3                        |
| Thickness ----- | 11.4                        | 10.5                        | 10.7                        | 9.5                         | 8.1                         | 6.3                         |

<sup>1</sup> USNM 168427 is from Cherry Creek.

<sup>2</sup> USNM 168423 and 168424 are from Enterprise Ditch.

<sup>3</sup> USNM 168427 is from Cherry Creek.

<sup>4</sup> USNM 168428 is from the Little Popo Agie River (colln. 38).

*Discussion.*—Shells of *C. sulcata* from the Amsden Formation resemble examples from the central Mississippi Valley region rather closely. Specimens from the so-called Brazer Limestone of Idaho identified by Girty (1927) as *C. sulcata* are somewhat thicker and have a longer and deeper sulcus in the pedicle valve, representing perhaps a subspecies of *C. sulcata*.

This species is distinguished from *C. poposiensis* n. sp., with which it occurs, by its subcircular to suboval shape, width normally greater than length, lack of lateral sulci and narrow bordering radial ridges in the pedicle valve, having long posterior margins that curve into the lateral margins without a clearly defined break in curvature, and by the very deep deflection of the line of commissure in mature specimens. Immature specimens are more difficult to distinguish from the less deeply sulcate forms of *C. poposiensis*, but are recognized by their wide shells and late-beginning median sulcus in the pedicle valve.

*Figured specimens.*—USNM 168423, 168424, 168455.

*Additional measured specimens.*—USNM 168425–168428.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 26a (5), 26b (10), ?34 (1), 35 (9), 36a (15), 36e (9), 38 (33), 42 (5), 43 (2), A (5), B (2), C (2), E (1), Fremont County.

*Composita ovata* Mather

Plate 10, figures 1–15, 26–32

*Composita ovata* Mather, 1915, p. 212, 213, pl. 14, figs. 6–6c; Dunbar and Condra, 1932, p. 370, 371, pl. 43, figs. 14–19; Gehrig, 1958, p. 13, pl. 5, figs. 5–13, 24–27, 38–40; Hoare, 1961, p. 90, 91, pl. 12, figs. 3, 4; Grinnell and

Andrews, 1964, p. 234–236, pl. 39, figs. 1, 2, 7, 8;

Sturgeon and Hoare, 1968, p. 57, 58, pl. 18, figs. 11–18.

*Composita subquadrata* (Hall). Easton, 1962, p. 78, 79, pl. 11, figs. 10–18.

*Diagnosis.*—Medium-sized *Composita* having subovate shell, greatest width at or just anterior to middle; sulcus shallow; fold low and broad. Pedicle valve moderately convex; brachial valve suboval to subcircular in outlines, approximately as convex as pedicle valve.

*Discussion.*—This is the common species of *Composita* in Amsden beds of Early Pennsylvanian (Morrowan) age. It is widely distributed in beds of Early Pennsylvanian age throughout the western United States. Specimens from the Alaska Bench Limestone of central Montana were described and figured by Easton (1962, p. 78, pl. 11, figs. 10–18) as *Composita subquadrata* (Hall).

The western specimens tend to be slightly more tumid than topotypes from the Morrowan Series in Arkansas, but their outline is about the same as that of the Arkansas shells. Perhaps the western form should be considered a geographic subspecies of typical *C. ovata*, but degree of tumidity, where this character is not excessive, is a will-of-the-wisp criterion upon which to base demarcation of a formal taxon.

Recent studies by Hoare (1961) and Sturgeon and Hoare (1968) have shown that this species ranges in Ohio from the lower Mercer Limestone of the Pottsville Group up to the Ames Limestone of the Conemaugh Group.

Dunbar and Condra (1932, p. 370, 371, table D) recognized this species at various levels throughout the Pennsylvanian rocks of Nebraska and Kansas,

ranging as high as the Lower Permian Wabaunsee Group.

The low broad sulcus and fold, causing only a shallow deflection in the anterior line of commissure is very characteristic of this species. Differences from *C. sigma* n. sp. are discussed under that species.

*Figured specimens.*—USNM 168434–168439.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 2 (1), 3 (8), ?4 (1), 5 (1), Carbon County. Ranchester Limestone Member: collections 13 (21), 14 (66), Carbon County; 68 (4), Sheridan County; ?87 (1), Lincoln County; ?130 (2), 131 (12), ?139 (1), 143 (5), Teton County.

*Composita elongata* Dunbar and Condra

Plate 10, figures 16–25

*Composita subtilita* (Hall). Sayre, 1930 [part], p. 102, pl. 6, figs. 4–6c [not 7–8c].

*Composita elongata* Dunbar and Condra, 1932, p. 371, 372, pl. 43, figs. 20–24; Grinnell and Andrews, 1964, p. 236, pl. 37, figs. 5, 6; pl. 38, figs. 5, 6; pl. 39, figs. 5, 6, 11, 21; Sturgeon and Hoare, 1968, 59, pl. 19, figs. 1–3.

*Description.*—Shell moderately small to medium sized having greatest width at or slightly anterior to midlength, maximum thickness slightly posterior to midlength; thickness approaching and in some specimens equaling width. Pedicle valve elongate oval in outline, rather strongly convex in side profile and more strongly convex in posterior profile. Sulcus shallow, arising about 10 mm in front of beak, meeting fold of brachial valve to produce moderately deep evenly rounded deflection in line of commissure. Beak incurved; posterior margins diverging at angles of 75° to 80°. Brachial valve suboval, shallower and less convex in side profile than pedicle valve but more narrowly arched in posterior profile; beak curving into delthyrium of pedicle valve, fold low and moderately broad, occupying most of anterior end. Surface of both valves smooth, marked by concentric grooves and lines of growth. Internal characters not observed.

*Dimensions (in mm).*—

|                 | USNM<br>168440 | USNM<br>168441 |
|-----------------|----------------|----------------|
| Length .....    | 19.3           | 18.7           |
| Width .....     | 14.7           | 13.3           |
| Thickness ..... | 14.7           | 12.5           |

*Discussion.*—The specimens described and figured from the Amsden Formation occur in a collection of Pennsylvanian (Morrowan) age in the Rawlins hills. They were found associated with *C. ovata* (Mather) and may intergrade with that species. Another speci-

men was found with *C. ovata* Mather at Hoback Canyon.

According to Sturgeon and Hoare (1968, p. 59), *C. elongata* intergrades with *C. subtilita* (Hall) in rocks of the Allegheny and Conemaugh Formations in Ohio. Grinnell and Andrews recognized *C. elongata* in the Missourian and Virgilian (Pennsylvanian) and Wolfcampian (Permian) Series. This evidence indicates that *C. elongata* may actually be a form species, composed of narrow variants of more than one species of *Composita* in Pennsylvanian and Lower Permian rocks. The Amsden shells constitute the earliest known record of this form.

*Figured specimens.*—USNM 168440, 168441.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collection 3 (7), Carbon County. Ranchester Limestone Member: collection 131 (1), Lincoln County.

*Composita subtilita* (Hall)

Plate 10, figures 33–37

*Terebratulata subtilita* Hall, 1852, p. 409, pl. 4, figs. 1a, b, 2a–e.

*Composita subtilita* (Hall). Girty, 1915a, p. 96–101, pl. 12, figs. 4–4c; pl. 5, fig. 7; pl. 6, fig. 13 (see for synonymy prior to 1915); Price, 1916, p. 706; Girty, 1920, pl. 54, figs. 27, 28; Price, 1921, p. 778 ?Plummer and Moore, 1921, pl. 6, fig. 17; pl. 19, fig. 7; Morningstar, 1922, p. 192, 193, pl. 8, figs. 10–13; Thomas, 1924, p. 478, pl. 2, figs. 23, 28–30; Morgan, 1924, pl. 42, figs. 13, 13a; Butts, 1926, p. 200, pl. 66, figs. 17, 18; Shimer, 1926, p. 78; Girty, 1927, pl. 27, figs. 34–36; Sayre, 1930, [part], p. 102, pl. 6, figs. 7–8e [not figs. 4–6c]; Branson, 1930, p. 38, pl. 9, figs. 8–11; King, 1930, p. 130, pl. 43, fig. 20, pl. 44, figs. 1, 2; Kelly, 1930, p. 147; Croneis, 1930, pl. 27, figs. 12–15; Morse, 1931, p. 314, pl. 50, fig. 6; Dunbar and Condra, 1932, p. 363–366, pl. 43, figs. 7–13; McKee, 1938, p. 262, 263, pl. 48, fig. 20; Cooper, in Shimer and Shrock, 1944, p. 335, pl. 128, figs. 9–12; Branson, 1948, p. 323; Allen and Lester, 1954, p. 19, 20, pl. 2, fig. 12; Gehrig, 1958, p. 13, 14, pl. 5, figs. 14–23, 28–37; Hoare, 1961, p. 89, 90, pl. 11, figs. 20–25; pl. 12, figs. 1, 2; Grinnell and Andrews, 1964, p. 235–237, pl. 37, figs. 3, 4, 7, 10, 11; pl. 38, figs. 1, 2; pl. 39, figs. 3, 4, 9, 10; Boucot and others, in Moore, 1965, p. H662, figs. 537, 2a–c; Sturgeon and Hoare, 1968, p. 57, pl. 18, figs. 5–10.

*Seminula subtilita* (Hall). French, 1940, p. 328, pl. 3, fig. 22.

*Description.*—Small to medium-sized *Composita*, suboval to subtriangular in outline, having greatest width anterior to and greatest thickness posterior to midlength; posterolateral margins forming acute angle. Sulcus and fold weak posteriorly and pronounced anteriorly, forming moderately deep rounded deflection in line of commissure. Beak in pedicle valve high, incurved, pierced at tip by circular foramen; beak in brachial valve small, buried in delthyrium of pedicle valve.

**Discussion.**—This ubiquitous species is not particularly common in the Amsden Formation of Wyoming. The specimen figured, from a bed of probable Morrowan age in the Gros Ventre Range, is typical. Two occurrences are in beds of Atokan age in the Rawlins hills.

**Figured specimen.**—USNM 168433.

**Occurrence and number of specimens.**—Ranchester Limestone Member: collections 6 (28), 15 (5), Carbon County; 136 (13), 141 (1), Teton County.

Suborder SPIRIFERIDINA  
Superfamily RETICULARIACEA Waagen  
Family ELYTHIDAE Fredericks  
Genus TORYNIFER Hall and Clarke, 1894

*Torynifer setiger* (Hall)?

Plate 13, figures 47, 48

*Spirifer setigerus* Hall, 1858, p. 705, pl. 97, figs. 4, 4a; Hall and Clarke, 1893, p. 21, 37; 1895, pl. 36, figs. 26, 27.

*Spirifera setigera* Hall. Hall and Whitfield, 1877, p. 270, pl. 5, figs. 17, 18; Hall, 1883, pl. (36) 61, figs. 26, 27; Keyes, 1895, p. 83.

*Reticularia setigerus* (Hall). Beede, 1906, p. 1318, pl. 21, figs. 1, 1a.

*Reticularia setigera* (Hall). Weller, 1914, p. 431–433, pl. 74, figs. 12–22; ?Girty, 1951b, p. 65, 66, pl. 4, fig. 6; Snider, 1915, p. 91; Branson, 1918, p. 102, pl. 4, figs. 14, 15; Girty, 1920, pl. 53, figs. 11, 12; ?Shimer, 1926, p. 67; Croneis, 1930, pl. 18, fig. 8, pl. 19, figs. 5, 6; Weller, 1931, pl. 43, figs. 9a, b; Gunnell, 1932, pl. 27, figs. 37, 38; Hernon, 1935, p. 688.

*Torynifer setigera* (Hall). Cooper, in Shimer and Shrock, 1944, p. 327, pl. 126, figs. 13–15.

*Torynifer setiger* (Hall). Minato, 1953, p. 70, 71.

An incomplete external mold of a brachial valve, from Livingston Ranch measuring approximately 23 mm long and 32 mm wide when complete, agrees in shape, size, and ornamentation with Hall's species. A latex cast of this specimen is figured and shows the concentric rows of spine bases clearly. The question mark applied to this identification records only a lack of material sufficient to verify the characters of the pedicle valve and of internal structure. Also belonging here is a young specimen about 9 mm long, from the Gros Ventre Range.

**Figured specimen.**—USNM 168456.

**Occurrence and number of specimens.**—Horseshoe Shale Member: collections 28 (1), 45 (1), Fremont County; 137 (1), Teton County.

Superfamily SPIRIFERACEA King  
Family SPIRIFERIDAE King  
Genus ANTHRACOSPIRIFER Lane, 1963  
*Anthracospirifer curvilateralis curvilateralis* (Easton)

Plate 11, figures 1–5

*Spirifer curvilateralis* Easton, 1962, p. 68–70, pl. 9, figs. 14–19.

*Spirifer increbescens* Hall. Easton, 1962, p. 70, pl. 9, figs. 20a, b.

*Spirifer shoshonensis* Branson and Greger. Easton, 1962 [part], p. 70, pl. 9, figs. 21a–c [not figs. 22a, b].

This species, here considered the typical subspecies, was described in detail by Easton in his report on the Carboniferous formations and faunas of central Montana. Its shell resembles that of *Anthracospirifer increbescens* (Hall) but normally is a little less transverse.

Easton's holotype, a specimen in early maturity, has the greatest width about 3 mm anterior to the hinge line, as do many other Late Mississippian examples of this species. Some Late Mississippian shells from the Heath Formation of Montana and most Pennsylvanian specimens referred to this species from formations overlying the Heath have their greatest width at the hinge line and their cardinal extremities acute. The lateral margins are well-rounded except just in front of the hinge, where they are pinched in slightly. The umbonal region extends well beyond the hinge line; the umbo is strongly incurved and overhangs the interarea.

On the typical mature shell, 5 costae occur in the sulcus, 6 on the fold, and 12 to 16 on each lateral slope. According to Easton, the number of costae ranges from 3 to 7 in the sulcus and 10 to 18 on each lateral slope. The average dimensions of seven mature specimens recorded by Easton are 23.3 mm long, 29.2 mm wide, and 18.2 mm thick.

A specimen from the Heath Formation of Montana figured by Easton (1962, pl. 9, figs. 21a–c) as *Spirifer shoshonensis* Branson and Greger came from the same collection as the primary types of *A. curvilateralis*. It is more alate than is typical in *A. curvilateralis* and in that respect resembles specimens from the "Cameron Creek" [actually from a Mississippian unit] assigned to *A. curvilateralis* by Easton. Three costae, the third to fifth to the left of the median sulcus give off a weaker plication ad-medially in this specimen. No similar splitting occurs on the right-lateral slope, the shell having 16 plications on one side of the sulcus and 13 on the other.

Easton's "*Spirifer shoshonensis*" is a pathologic specimen, regarded here as a topotype of *A. curvilateralis*. It does not closely resemble the syntypes of *Anthracospirifer shoshonensis* (Branson and Greger), with which I have compared it, differing in the *A. increbescens*-like shape and the narrowly rounded costae that are separated by rounded furrows. *A. shoshonensis* has subangular costae separated by V-shaped furrows and a narrow and very shallow median sulcus indenting a rather deep pedicle valve. It is a characteristic species in the Bull Ridge Mem-

ber of the Madison Limestone and is restricted to rocks of early Meramecian age.

Another rather alate *Anthracospirifer* from the Cameron Creek Formation was figured by Easton (1962, p. 70, pl. 9, fig. 20a, b) as *Spirifer increbescens* Hall. This specimen, which has 7 costae in the sulcus and 15 on each lateral slope on the pedicle valve, was the only central Montana example referred by Easton to Hall's species. In my opinion, it falls within the range of variation of *A. curvilateralis* rather than that of *A. increbescens*, although the two are closely related species.

Although most of the *A. curvilateralis*-like spirifers in the Moffat Trail Limestone Member of the Amsden Formation belong in a new coarse-ribbed subspecies, described below, specimens at three localities resemble the holotype of *A. curvilateralis* in shape and have 12 to 14 costae on each lateral slope. These more finely costate specimens are referred to *A. curvilateralis curvilateralis*.

*Figured specimen*.—USNM 167735.

*Occurrence and number of specimens*.—Moffat Trail Limestone Member: collections 92 (1) Lincoln County; ?121 (2), 145 (55), Teton County.

*Anthracospirifer curvilateralis brutus* n. subsp.

Plate 11, figures 6–12

*Diagnosis*.—Moderate-sized, rather tumid *Anthracospirifer* having strongly convex lateral slopes as in *A. curvilateralis* Easton, but more coarsely ribbed, 17 to 25 costae occurring typically on pedicle valves.

*Description*.—Pedicel valve strongly convex, greatest convexity near umbo, and lessening toward anterior margin; subcircular to transversely suboval in outline; greatest width at or just anterior to hinge; in posterior view, lateral slopes strongly convex at either side of median sulcus, less convex but strongly inclined near cardinal extremities. Sulcus broadly V-shaped posteriorly, becoming rather evenly concave anteriorly; anterior margin indented strongly by tongue-like extension of sulcus. Lateral margins well rounded, curving toward hinge to form slightly acute to slightly obtuse angle at cardinal extremities. Beak strongly incurved, overhanging interarea, which is markedly concave in lateral profile; interarea longitudinally grooved, bearing row of fine teeth along anterior margin at either side of triangular delthyrium.

Surface ornamented by 3 prominent rounded costae within sulcus and 7 to 11 on each lateral slope, separated by subequal, moderately deep rounded furrows; costae resemble plications and cause serration along line of commissure. Silicification in primary types has obliterated microornament.

Internally, pedicle valve has pair of fairly short narrow dental lamellae within umbonal region, where shell is moderately thick. Muscle-scar area within pedicle valve roughly rhombic in shape.

Internally, pedicle valve has pair of fairly short narrow dental lamellae within umbonal region, where shell is moderately thick. Muscle-scar area within pedicle valve roughly rhombic in shape.

Brachial valve less convex than pedicle valve but appearing moderately convex in anterior profile. Fold moderately elevated, subrounded, marked by four rounded costae; lateral slopes with 6 to 10 costae.

*Dimensions (in mm)*.—

|              | USNM<br>167736 | USNM<br>167737 | USNM<br>167738 | USNM<br>167739 |
|--------------|----------------|----------------|----------------|----------------|
| Length ----- | 26             | 22.5           | 21             | 13             |
| Width -----  | 30             | 24             | 29.5           | 17             |
| Thickness -- | 20.5           | <sup>1</sup> — | 17             | 10             |

<sup>1</sup> Pedicle valve only; depth=12.5 mm.

*Discussion*.—*Anthracospirifer curvilateralis brutus*, although agreeing with Easton's species in shape, has fewer ribs than are generally present in the Montana form. The holotype has only 3 costae in the sulcus and 7 on each lateral slope, as contrasted to the normal 5 in the sulcus and 12 to 16 on each lateral slope for typical pedicle valves of *A. curvilateralis*. The range of variation of the two forms overlaps slightly, however, at 3 in the fold and 10 or 11 on each lateral slope.

This subspecies is based on five specimens from two localities in the Moffat Trail, about 30 miles apart. The holotype is a nearly complete shell from the Moffat Trail section.

Included tentatively with *A. c. brutus* are specimens that occur abundantly in a limestone bed in the Horseshoe Shale Member immediately below the Moffat Trail Limestone Member in the section at Hoback Canyon. These actually are intermediate in their ribbing between typical *A. curvilateralis* and *A. c. brutus*, most of them having 5 costae in the sulcus and 10 or 11 on each lateral slope; they have the characteristic microornament of *Anthracospirifer*. A few show splitting of the costae that are near the sulcus. This occurs in the one figured on plate 11, figure 6, which has two costae added by bifurcation on one side of the sulcus but not on the other. No specimen assigned here to *A. c. brutus* has more than 11 costae on each lateral slope. All so assigned occur below the base of the Ranchester Limestone Member in western Wyoming.

*Types*.—Holotype, USNM 167736; paratypes, USNM 167737–167742.

*Occurrence and number of specimens*.—Moffat

Trail Limestone Member: collections 775 (1), 776 (1), 77 (2), 78 (3 paratypes), 79 (1), 109 (holotype and paratype), Lincoln County. Horseshoe Shale Member: collections 117 (35), 118 (80), Teton County.

*Anthracospirifer occiduus* (Sadlick)

Plate 11, figures 24–32

*Spirifer boonensis* Swallow, 1860, p. 646.

*Spirifer boonensis* Swallow? Girty, 1903, p. 381–383, pl. 6, figs. 1–3; Morningstar, 1922, p. 186, 187, pl. 9, figs. 21–25.

*Spirifer opimus* Hall var. *occidentalis* Girty, 1927, p. 433, 434, pl. 27, figs. 28–31 [not *S. occidentalis* Kindle 1908].

*Spirifer occidentalis* Girty. Dunbar and Condra, 1932, p. 322–326, pl. 41, figs. 12–16; Foster, 1942, p. 249, 250, text fig. 1; Gehrig, 1958, p. 15, 16, pl. 3, figs. 7–18.

*Spirifer occiduus* Sadlick, 1960, p. 1210, 1211, table 1 [new name for *S. occidentalis* Girty, not Kindle]; Spencer, 1967, p. 18–20, figs. no. 3, 9; 12.

*Anthracospirifer occiduus* (Sadlick). Lane, 1963, p. 388; 1964, p. 781–785; Sturgeon and Hoare, 1968, p. 62, pl. 20, figs. 1–7.

**Diagnosis.**—Rather large *Anthracospirifer*, considerably wider than long, greatest width at hinge; valves equally convex, sulcus moderately shallow; fold high, fairly broad, and well defined. Mature pedicle valves ornamented by 25 to 33 costae, 2 or 3 near sulcus commonly bifurcate.

**Description.**—Pedicule valve rather strongly convex in side profile, curvature greatest in umbonal region, becoming gradually less toward convex anterior margin; broadly and rather gently arched in posterior profile, shallowly indented by median sulcus. Sulcus moderately broad anteriorly and curving dorsally to fit into fold of brachial valve. Antero-lateral and lateral margins fairly straight or gently convex in outline, commonly steepening toward hinge; cardinal extremities narrowly to broadly acute. Interarea fairly low; umbo somewhat depressed; beak incurved.

Surface of pedicle valve sculpture by rounded costae separated by slightly narrower intercostal grooves; 5 of these occurring in sulcus, middle one commonly larger than others; 12 occurring on each flank in type lot; first 2 costae at either side of sulcus are bifurcated near umbo, next 2 primary costae typically giving off additional costa on proximal side by bifurcation on lateral slopes. Microornament, where visible, consists of concentric growth lirae crossed by fine longitudinal lirae to form cancellate pattern.

Brachial valve having same convexity as pedicle valve except along fold, which is less convex; fold broad, elevated, and slightly produced, set off by

grooves at either side, of strength subequal to intercostal grooves. Costae similar to those on pedicle valve, 6 normally occurring on fold and 11 on each lateral slope. First costa at either side of fold is undivided, but next two primary costae split early on lateral slopes. Furrow marking center of fold slightly wider than intercostal grooves at either side. Costae on internal mold appearing much sharper and elevated than on exterior of shell. Interior of brachial valve not clearly shown in type lot.

*Dimensions (in mm).*—

|                         | USNM<br>118717A | USNM<br>118717B | USNM<br>118717C |
|-------------------------|-----------------|-----------------|-----------------|
| Length -----            | 28              | 30              | 23.5            |
| Maximum width -----     | 44              | 48              | 42              |
| Thickness -----         | 19              | —               | —               |
| Depth (one valve) ----- | —               | 13              | 9               |

<sup>1</sup> USNM 118717A is lectotype retaining most of both valves.

<sup>2</sup> USNM 118717B is pedicle valve paralectotype.

<sup>3</sup> USNM 118717C is brachial valve paralectotype.

<sup>4</sup> Twice the half length.

<sup>5</sup> Slightly less than actual thickness because of crushing.

**Discussion.**—The description above is based on Girty's original specimens from the Wells Formation in the Crow Creek quadrangle, Idaho (USGS loc. 32–PC, sec. 35, T. 9 S., R. 45 E.). The most complete specimen figured by Girty (1927, pl. 27, figs. 28, 29) was selected by Sadlick (1960, p. 1210) as the lectotype and is figured together with two paralectotypes on plate 11, figures 24–30. Four additional unfigured paralectotypes are in the National Museum collection (USNM 167743). A hypotype from Hoback Canyon figured on plate 11, figures 31, 32, shows the dental ridges flanking the delthyrium on either side and extending forward as short teeth that engage with the brachial valve; also the deeply impressed lenticular area in which the adductor muscles are attached.

Lane (1964) has discussed the variation in costation that is present in this and related species. Normally 5 or 7 costae occur in the sulcus, 6 or 8 on the fold, and 9 to 16 on each lateral slope. Actually, mature specimens of *A. occiduus* with more than 13 and less than 11 costae on each lateral slope are relatively rare. The subacute cross section of the costae on internal molds is one of the peculiarities of this species. A tendency for some of the costae to bifurcate is also characteristic, at least so far as western specimens are concerned. In specimens from the American midcontinent, such bifurcation is very rare. It might in fact, be possible to recognize a western and eastern subspecies of *A. occiduus* or two distinct species based on this difference, but pending further study both forms are included in the same taxon.

**Comparisons and affinities.**—*A. occiduus* differs from *A. curvilateralis* (Easton) in its relatively

shorter and more transverse shell (the greatest width occurring invariably at the hinge) and its higher, more prominent fold. The broad gentle arching of the pedicle valve of *A. occiduus*, viewed from the posterior, contrasts with the convex and sloping flanks of *A. curvilateralis*. In the western form of *A. occiduus* the tendency of the costae near the sulcus to split also differs from *A. curvilateralis*, in which bifurcation of the costae is a rarity.

*A. matheri* (Dunbar and Condra) is a closely related species having approximately the same number of costae on each lateral slope as *A. occiduus*, some of which, like those on the fold and sulcus, tend to bifurcate. Examination of topotypes from the Brentwood Limestone Member of the Bloyd Shale of northwest Arkansas shows that it is a somewhat smaller species than *A. occiduus*, having 5 to 9 plicae in the sulcus, 6 to 10 on the fold, and 10 to 13 on each lateral slope in fully mature shells. Bifurcation of the plicae in *A. matheri* tends to be irregular. Commonly, an extra plica will develop on one slope of the fold and sulcus but not on the other, resulting in an odd number of plicae on the fold and an even number in the sulcus. Also, a plica may bifurcate on one lateral slope and a different plica on the other lateral slope in the same valve. No specimens were observed showing bifurcation in the same direction of two adjacent plicae, as is common in *A. occiduus*.

*A. opimus* (Hall) is a narrower species having subparallel lateral margins that give it a subrectangular shape. It has fewer costae and costellae than *A. occiduus*, normally four costae occurring on the fold.

Although *A. occiduus* was commonly identified as *A. rockymontanus* (Marcou) by 19th century paleontologists, little similarity exists between the small subcircular shell of the Rocky Mountains species, as established by the designation by Girty (1903, p. 384) of a lectotype for Marcou's species, and the moderately large transverse shell of *A. occiduus*.

*Types*.—Lectotype, USNM 118717A; paralectotypes, USNM 118717B, C, 167743 (seven paratypes in all); hypotype, 167744.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 1 (1), 5 (2), Carbon County. Ranchester Limestone Member: collections 6 (21), 14 (3), ?15 (3), Carbon County; 83 (3), 84 (3), ?89 (3), 99 (1), 100 (2), ?101 (1), Lincoln County; 133 (1), Sublette County; 131 (3), ?140 (1), 141 (1), Teton County.

*Anthracospirifer* aff. *A. occiduus* (Sadlick), form A  
Plate 11, figures 19, 20

*Spirifer shoshonensis* Branson and Greger. Easton [part], 1962, p. 70, pl. 9, figs. 22a, b [not figs. 21a-c].

Partly crushed transverse shells of *Anthracospirifer* in reddish-gray shale of latest Mississippian age at the north end of the Teton Range are much like *A. occiduus* in some respects, but they also have several characters that differentiate them from typical *A. occiduus*. Mature examples of these spirifers reach 50 mm in width and more than 26 mm in length. Because of crushing, the overall thickness of these shells is not known, but some of the pedicle valves have a general shape similar to that of *A. occiduus*.

Pedicle valves are commonly alate, some with very acute cardinal extremities, the greatest width of the shell invariably at the hinge. The beak is incurved but does not overhang the interarea markedly. Viewed posteriorly, the pedicle valve has rather low convexity and the median sulcus is shallow. Similarly, in the brachial valve the fold is low and moderately broad; plications are low, subrounded, with narrower rounded grooves between. Typically, 3 or 5 plications occur in the sulcus, 4 or 6 in the fold, and 14, rarely 15, on each lateral slope. As in *A. occiduus*, the three primary plications at either side of the sulcus tend to split into two. The first, which borders the sulcus, splits near the beak, and the next two give off a weaker plication admedially, a few millimeters forward on the valve. Microornament consists of fine radial lirae crossed by concentric striae and lamellae of growth.

The Berry Creek shells resemble *A. occiduus* in the moderately low convexity of pedicle valves and in the pattern of splitting of the major plications on the lateral slopes. They differ from that species, however, in the very shallow median sulcus of the pedicle valve and lower fold of the brachial valve and in having a couple more plications on each lateral slope. Nor are the plications subangular internally and on the inside of the shell as is typical in *A. occiduus*. In the absence of complete or well enough preserved specimens for a thorough comparison with *A. occiduus* and related species, the problem whether these shells (1) should be included within *A. occiduus* s.l., (2) should constitute a subspecies of *A. occiduus*, or (3) are a distinct species cannot be resolved here.

A unique *Anthracospirifer* from the Cameron Creek in Fergus County, Mont. was figured by Easton (1962, p. 70, pl. 9, figs. 22a, b) as *Spirifer shoshonensis* Branson and Greger. This specimen (USNM 118809) is identical in shape, shallow sulcus, splitting pattern, and number of plications with the Berry Creek shells. Although present in beds now thought to be Pennsylvanian in age (Maughan and Roberts, 1967, pl. 4), its stratigraphic position



is near the Mississippian-Pennsylvanian boundary. The Berry Creek specimens are likewise near this boundary, as latest Mississippian Zone 19 Foraminifera have been identified by Mamet (1975) in the same beds.

*Anthracospirifer* aff. *A. occiduus*, form A, may, therefore, be a distinct form that precedes typical *A. occiduus* in stratigraphic sequence in this part of the Rocky Mountain region. On the other hand, as all our specimens of *A. aff. A. occiduus* form A, are from shale beds and all our specimens of typical *A. occiduus* are from limestone, chert, and calcareous siltstone beds, the possibility of facies control of the observed differences cannot now be eliminated.

*Figured specimens.*—USNM 167745.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 26a (1), Fremont County; 149 (7), 150 (5), ?151 (2), 152 (10), 153 (18), 155 (1), 156 (5), 157 (5), 158 (2), Teton County.

*Anthracospirifer* aff. *A. occiduus* (Sadlick), form B

Plate 11, figures 21–23

*Anthracospirifer* in two collections from the west slope of the Teton Range are related to *A. occiduus* but differ from it in shape in the direction of *A. increbescens* (Hall). The outline of the pedicle valve is less transverse than in typical *A. occiduus*, the lateral margins more rounded, and the cardinal extremities terminating in short points. In posterior view the shell is rather flat in the middle, the sulcus appearing as a shallow rounded depression at the center. Beyond the nearly flat area the lateral slopes are strongly convex, then become concave near the cardinal extremities. The beak is fairly low and incurved.

The figured specimen is typical. It has 5 costae in the sulcus and 14 on each lateral slope. Primary costae at either side of the sulcus are bifurcate as in *A. occiduus*. Brachial valves are scarce. On them the fold is moderately elevated and bears six costae.

*Anthracospirifer* aff. *A. occiduus*, form B, is narrower and its pedicle valve is more convex transversely than form A. Like form A, these shells are in rocks of probable latest Mississippian age, but the possibility of these two collections coming from rocks of Early Pennsylvanian age cannot be entirely eliminated.

*Figured specimen.*—USNM 167746.

*Occurrence and number of specimens.*—Ranchester Limestone Member: collections 146 (85) and 148 (12), Teton County.

*Anthracospirifer rawlinsensis* n. sp.

Plate 11, figures 13–18

*Diagnosis.*—Medium-sized spirifer; length and width subequal, greatest width at or near hinge line; cardinal extremities subrectangular; sulcus broadly V-shaped in cross section. Mature pedicle valves ornamented by 37 to 39 costae.

*Description.*—Pedicel valve strongly convex, greatest convexity posterior to middle, transversely suboval to subrhombic in outline, width usually slightly greater than length; lateral slopes fairly steep; margin rounding toward hinge and meeting it approximately at right angles. Median sulcus broad, equal to about one-fourth width of shell at midlength, moderately deep to fairly shallow, broadly V-shaped posteriorly, becoming concave anteriorly and extending forward and upward beyond plane of commissure in prominent tonguelike deflection of margin that fits into fold of brachial valve. Umbo incurved and overhanging interarea; umbonal slopes moderately steep; umbonal angle about 110°. Interarea moderately high, concave in lateral profile. Shell exceeds 2 mm in thickness over much of umbonal region.

Surface sculpture in pedicle valve consisting of 7 low rounded costae in sulcus and 15 or 16 on each lateral slope; costae separated by narrower shallow rounded furrows. Central costa in sulcus begins at tip of umbo and three at either side split off at regular intervals from major costa that delimits sulcus at either side. Bifurcation generally affects three primary costae at either side of sulcus and in rare instances, takes place randomly. Micro-ornament consists of moderately strong growth lamellae crossed by faint capillae (seen only in one small patch near anterior margin of holotype).

Interior of pedicle valve without well-developed dental lamellae. Muscle scars occupying elongate rhombic area within umbonal region bordered by pair of curved raised ridges that unites anteriorly in single broad ridge along inside of sulcus. Interior of lateral slopes with a few longitudinal ridges separated by wider concave interspaces.

Brachial valve less convex than pedicle valve. Fold beginning at beak, moderately low and rounded, set off from lateral slopes by furrows that are wider than intercostal furrows; fold becoming higher anteriorly but not necessarily better demarcated because inclination of lateral slopes increases to degree that break in slope at base of fold is slight. Ornamentation of costae and furrows similar to those in pedicle valve.

*Dimensions (in mm).—*

|                | Holotype <sup>1</sup><br>USNM<br>167747 | Paratype<br>USNM<br>167749 | Paratype<br>USNM<br>167750 | Paratype<br>USNM<br>167753 |
|----------------|---|----------------------------|----------------------------|----------------------------|
| Length -----   | 32                                      | <sup>2</sup> 22            | 19                         | <sup>2</sup> 26            |
| Width -----    | 36                                      | 28.5                       | 23                         | 22.5                       |
| Depth -----    | 15                                      | 8                          | 8                          | —                          |
| Thickness ---- | —                                       | —                          | —                          | 17.5                       |

<sup>1</sup> First three are pedicle valves; last is articulated shell lacking beak area.

<sup>2</sup> Estimated.

*Discussion.*—*Anthracospirifer rawlinsensis* n. sp. is represented by six pedicle valves and one fragment of a brachial valve from one U.S. Geological Survey collection and a narrow articulated specimen lacking the beak and part of the fold, from another, both from localities in the Rawlins hills. A mature pedicle valve has been selected as the holotype.

The identifying characters of this species are its relatively narrow shape, broadly V-shaped median sulcus in the pedicle valve, and the relatively large number of costae that ornament both valves. These characters enable it to be separated rather easily from other Amsden spiriferoid species.

This species resembles *Spirifer adonis* Bell from the Windsor Series (Subzone C) of Nova Scotia in its general shape and similar costation. It differs from that species in having a slightly less convex pedicle valve, less incurved beak, higher interarea, longer hinge line and subangular rather than rounded cardinal extremities. The beds containing *S. adonis* are late Viséan (=early Chesterian) in age, according to a study of their small Foraminifera by Mamet (1970).

Approximately the same number of costae occurs, however, in another Wyoming species, *Anthracospirifer shoshonensis* (Branson and Greger), from the Bull Ridge Member of the Madison Limestone, of early Late Mississippian age. Pedicle valves in the type lot of that species, with which our specimens of *A. rawlinsensis* have been directly compared, bear 33 to 41 costae. *A. shoshonensis* can be distinguished from *A. rawlinsensis* by its more transverse shell, its narrow and very shallow median sulcus, normally containing five costae, the subangularity of its costae, and a strong tendency for them to split somewhat randomly, producing odd and unbalanced combinations locally in some specimens, such as six costae in the sulcus and seven on the fold. In one of the primary types of *A. shoshonensis* the median costa in the sulcus is bifurcated. In *A. rawlinsensis*, splitting of the plications is more regular and largely confined to those on the lateral slopes near the sulcus and fold.

*Types.*—Holotype, USNM 167747; paratypes, USNM 167748–167753.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 3 (holotype and five paratypes), 4 (paratype), Carbon County.

*Anthracospirifer shawi shawi* n. subsp.

Plate 12, figures 25, 29–33, 37–42

*Spirifer pellaensis* Weller. Branson and Greger, 1918 [part], p. 317, pl. 18, fig. 7 [not figs. 8, 9].

*Diagnosis.*—Small, moderately transverse *Anthracospirifer*, having cardinal extremities acute or rarely tending toward subrectangular; sulcus moderately deep and fold high and narrow. Adult shells normally having 17 to 21 prominent rounded costae on pedicle valve, separated by rather deep furrows.

*Description.*—Shell wider than long, moderately alate, greatest width at hinge; cardinal extremities typically acute, commonly extended as short points, but approaching rectangular in some specimens. Pedicle valve moderately to strongly convex in side profile, greatest curvature near beak and decreasing slightly anteriorly; umbo not strongly incurved; beak suberect to erect. Valve broadly arched in posterior profile, indented by median sulcus that begins at umbo, V-shaped in cross section posteriorly, more evenly concave anteriorly, extended as flat tongue to fit into fold of brachial valve. Lateral slopes rounding rather strongly toward cardinal extremities; lateral margins becoming less rounded and slanting posterolaterally toward cardinal extremities. Interarea low to moderately high, gently concave in side profile, meeting plane of commissure at angle of approximately 150°, more highly convex near beak; delthyrium wider than high, occupying slightly less than one-fifth of width of hinge line.

Surface sculpture on pedicle valve consisting typically of three costae within sulcus, four on fold, and seven to nine on each lateral slope in adult shells. Costae are well rounded, rather broad, and separated by deep and narrow intercostal furrows; typically, they do not bifurcate on lateral slopes. Within initial part of sulcus, a median costa is the only one present; at distance of 6 to 7 mm from beak, two more split off from costae delimiting each side of sulcus, in manner typical of *Anthracospirifer* and related genera.

Brachial valve nearly as convex as pedicle valve, alate. Fold beginning at beak, narrow and rather low, becoming rather highly elevated in anterior two-thirds of valve, set off from lateral slopes by furrows that are no wider than intercostal furrows. Ornamentation of costae and furrows similar to those in pedicle valve.

*Dimensions.*—The only two undistorted specimens available, the holotype and a paratype (USNM

167757), measure respectively (in mm) : length 17.2, 17.0, maximum width 23.8, 24.5; and thickness (both valves) 13.7, 13.0.

*Discussion.*—This species is based mainly on shells from the general vicinity of the Little Popo Agie River, including Cherry Creek. The holotype is the smallest of three specimens described and figured by Branson and Greger (1918, p. 137, pl. 18, figs. 7–9) as *Spirifer pellaensis* Weller. It is a calcareous specimen and, as has been pointed out earlier in this report, the calcareous brachiopod shells at Cherry Creek and its vicinity appear to have come from the lower fossiliferous zone (*Carlinia amsdeniana* Subzone). The other two specimens figured by Branson and Greger are silicified and are regarded as belonging in a more advanced subspecies of *A. shawi*, one of them being designated as the type specimen of the subspecies.

Designated paratypes include two specimens collected by Keyte at Enterprise Ditch (colln. A) and six others from an undisclosed locality in Fremont County (colln. F), as well as the specimen illustrated on plate 12, figure 25, from the section at Darwin Peak, Teton County. This species is named for Alan B. Shaw in recognition of his work on the Paleozoic rocks of Wyoming.

All the specimens that have the characters of typical *A. shawi shawi* are calcareous shells; only two calcareous specimens, from an unknown locality in Fremont County, are assigned to the subspecies *A. s. exoletus*. This would seem to indicate that *A. shawi shawi* is restricted to the *Carlinia amsdeniana* Subzone in the type region and that the more advanced subspecies, if present at all in this subzone, is rare.

This subspecies is fairly easily distinguished from *A. welleri welleri*, the more common *Anthracospirifer* in the same subzone, which differs in having a subcircular shell with rounded cardinal extremities, a lower fold and shallower sulcus, and narrower and more numerous costae on the lateral slopes.

*Types.*—Holotype, 2651B; paratypes, USNM 163711, 163712, 167757, 167758 (nine paratypes in all).

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 26b (1), 36b (1), 43 (5), 45 (10), 49 (16), A (2), E (2), F (6), Fremont County; 137 (7), 138 (1), Teton County.

*Anthracospirifer shawi exoletus* n. subsp.

Plate 12, figures 26–28, 34–36, 43–47

*Spirifer pellaensis* Weller. Branson and Greger, 1918 [part], p. 317, pl. 18, figs. 8, 9 [not fig. 7].

*Spirifer opimus* Hall. Burk, 1954 [part], p. 11, pl. 1, figs. 16–18, 20–22 [not fig. 19].

*Spirifer* sp. Burk, 1954, p. 11.

*Diagnosis.*—Like *Anthracospirifer shawi shawi*, but somewhat larger and having more numerous costae in sulcus and on lateral slopes, typically 23 to 27 on each valve; some costae (rarely) tend to bifurcate.

*Description.*—Shell medium-sized, moderately transverse and alate. Both valves rather strongly convex in side profile. Sulcus in pedicle valve moderately deep; fold in brachial valve high and fairly narrow.

Surface sculpture on pedicle valve consisting of 5 costae (rarely 3) in sulcus, 6 costae (rarely 4) on fold, and 10 to 11 on lateral slopes. Costae less broadly rounded than in typical form; intercostal furrows rounded, subequal in width to costae. Splitting of costae occurs on some shells, most commonly involving third costa from sulcus by addition of another costa on proximal side. In sulcus, second and third costae split off 4 to 5 mm anterior to tip of umbo; next pair is added 10 to 12 mm further forward. Fine radial lirae, typical of the microornament of *Anthracospirifer* is visible on some specimens (see pl. 12, fig. 43).

*Discussion.*—*Anthracospirifer shawi exoletus* is the common spirifer of the *Composita poposiensis* Subzone in the Wind River Range. Brachiopods in this subzone are generally silicified. Although this subspecies is more common than the typical form, unbroken and undistorted specimens are not known.

The holotype is the specimen, 37 mm wide, figured as *Spirifer pellaensis* by Branson and Greger (1918) on plate 18, figure 9; it is refigured here on plate 12, figure 35. It is partly crushed and distorted so as to overemphasize the acuteness of the cardinal extremities, but is the most complete specimen available. A paratype of this subspecies, from Cherry Creek, also figured by Branson and Greger (1918, pl. 18, fig. 8), is shown here on plate 12, figure 34. Other paratypes, some of which are also figured in this report, include two calcareous USNM shells collected by Keyte (colln. F), four silicified shells from Cherry Creek, figured by Burk (1954) as *Spirifer opimus* (colln. 35), and nine additional specimens from a collection made by Henbest at Little Popo Agie Canyon (colln. 38).

Direct comparison of the shells figured by Burk (1954) as "*Spirifer opimus* Hall" with those figured by Branson and Greger (1918) as "*S. pellaensis* Weller" shows that they belong in the same species, with a single exception—the one figured by Burk on his plate 1, figure 19, is a specimen of *Anthracospiri-*

*fer welleri welleri* (Branson and Greger). Shaw and Bell (1955, p. 335, fig. 1) followed Burk in identifying the spirifer of the upper zone (*Composita popo-siensis* Subzone of this report) as *S. opimus* Hall, but Shaw (1955, p. 60), discussing the fossils of the upper zone, referred to them as the *Spirifer* "*opimus*" fauna. He cited a letter in which Sadlick suggested that this might be a species related to *A. leidy* (Norwood and Pratten) and a precursor of true *A. opimus* and said that he agreed with this opinion. Sadlick (1955, p. 56) also stated the same opinion.

*Anthracospirifer opimus* (Hall) was described originally from the Coal Measures of Ohio, Maryland, and Iowa and differs from *A. shawi exoletus* in its constant subrectangular shape, broader and lower fold, and fewer costae (it normally has three in the sulcus, four on the fold, and eight on each lateral slope).

*Anthracospirifer pellaensis* Weller differs from *A. shawi exoletus* in its narrower and more numerous costae, slightly lower interarea, and prominent concentric lamellae along the anterior slopes in both valves. The Iowa species is more variable in shape than *A. shawi* and includes decidedly alate shells with as many as 18 costae on each lateral slope, as well as narrower forms with fewer costae. No more than 11 costae on each lateral slope occur in our Wyoming shells.

*Types*.—Holotype, UM 2651A; paratypes, UM 3533, UW IT-202 to 205, inclusive, USNM 167754-167756, 174071.

*Occurrence and number of specimens*.—Horseshoe Shale Member: collections 19 (1), 26a (7), 26b (11), 29 (3), 32 (4), ?34 (3), 35 (85), 36a (1), 36b (1), 36e (23), 38 (41), ?48 (1), F (2), Fremont County. Ranchester Limestone Member: collection 82 (2), Lincoln County.

*Anthracospirifer welleri welleri* (Branson and Greger)

Plate 12, figures 1-24

*Spirifer welleri* Branson and Greger, 1918, p. 317, 318, pl. 18, figs. 10, 11, 18; C. Branson, 1937, p. 652.

*Rhipidomella gregeri* C. Branson 1937 [part], p. 655, pl. 89, figs. 16, 17.

*Spirifer opimus* Hall. Burk [part], 1954, p. 11, pl. 1, fig. 19 [not figs. 16-18, 20-22].

Not *Spirifer welleri* Branson and Greger. Easton, 1962, p. 70, pl. 9, fig. 23.

*Diagnosis*.—Small, moderately tumid *Anthracospirifer*; length and width subequal; hinge short; cardinal extremities rounded to obtusely subangular; sulcus shallow and fold low; typically with 21 to 27 narrow costae on pedicle valve.

*Description*.—Pedicule valve subcircular in outline, greatest width at or near midlength; lateral margins rounding toward hinge and meeting it at obtuse angle; valve fairly deep, strongly convex both in side and posterior profiles, greatest convexity posterior to middle, opposite hinge. Beak rather strongly incurved; interarea concave posteriorly, nearly flat anteriorly, poorly delimited posterolaterally where umbonal slopes curve to meet it, height of interarea equal to approximately one-third its length; pierced by triangular delthyrium, base of which occupies nearly one-third length of hinge-line. Sulcus shallow, fairly broad, gently concave in cross section, begins at umbo and extends to anterior margin where it produces shallow deflection. Surface of valve marked by low rounded to subangular costae separated by subequal rounded furrows; normally 3 costae occurring in sulcus and 9 to 11, rarely 12, on each lateral slope. Interior of pedicle valve micro-ornament of *Anthracospirifer*. As pointed out muscle-scar field narrow, elongate.

Brachial valve transversely suboval in plan, less convex than pedicle valve. Median fold fairly low, not elevated at all at beak, set off from rest of valve by bordering furrow at either side that is slightly wider than those between costae. Fold normally bearing 4 costae; 8 to 11 occurring on lateral slopes as in pedicle valve. Micro-ornament in both valves consists of fine radial lirae crossed by fine incremental striae and weak growth lamellae.

*Dimensions (in mm)*.—

|                 | Paralectotype | Lectotype | Paralectotype |
|-----------------|---------------|-----------|---------------|
| Height -----    | 16.5          | 15.5      | 12.5          |
| Width -----     | 18.0          | 16.7      | 16.5          |
| Thickness ----- | 11.0          | 11.6      | 9.0           |

*Discussion*.—Three syntypes in the collection of the University of Missouri (UM 3532), upon which Branson and Greger (1918, p. 317, pl. 18, figs. 10, 11, 16) based their description and illustrations of the typical form of this species, are refigured in this report (pl. 12, figs. 1-12, 14-19). The specimen figured by Branson and Greger in their plate 18, figure 16, is hereby designated the lectotype. It is the most typical of the three shells. The other two specimens constitute the paralectotypes, of which the one figured by Branson and Greger on their plate 18, figure 10, is slightly better preserved than the lectotype and preserves the microornament. This specimen is, however, a bilaterally asymmetrical pathologic specimen. The interarea is considerably wider on one side than on the other; it has 12 costae on one lateral slope of the pedicle valve and 10 on the other. The third specimen is slightly more transverse and less tumid than is normal in this species.

The measurements of all three specimens are given in the table above.

Specimens from the Popo Agie River in the early neanic growth stage were described and figured by C. C. Branson as "*Rhipidomella gregeri* n. sp." Radial striations and closely spaced growth lines described by Branson as marking the surface of shells at an average length of 0.8 mm constitute the typical micro-ornament of *Anthracospirifer*. As pointed out in Branson's description, the fold and sulcus are just beginning to appear in these specimens.

The holotype and paratype of *R. gregeri*, figured in Branson's paper, have unfortunately suffered the ravages of time, one valve missing and the other apparently damaged, but another "cotype" (UM 6593) and nine "metatypes" (UM 6613) show the characters at this stage very well. Another shell, also in the University of Missouri collection, labeled as a "cotype" of *R. gregeri* (UM 6585), is a tiny terebratuloid having a finely punctate smooth shell.

The central Montana records of this species (Easton, 1962, p. 70, pl. 9, fig. 23), some of them from beds now believed to be Pennsylvanian in age (Maughan and Roberts, 1967, p. B20-B23), are not considered valid. Easton, in fact, questioned two of his three identifications of *Spirifer welleri*. The small fragmental pedicle valve from the Heath Formation (USGS colln. 13414-PC) is not complete enough to be identified. Easton's figured specimen from the Alaska Bench Limestone (USGS colln. 13404-PC) resembles *A. welleri*, but its cardinal extremities have been broken off, and the shell is less tumid than is typical for *A. welleri*; like the last, it cannot be identified with certainty as to species. Two other specimens from the Alaska Bench Limestone (USGS colln. 13404-PC) are transverse, alate shells with acute cardinal extremities and should be referred to *A. occidentalis* (Sadlick).

*Comparisons and affinities.*—*Anthracospirifer welleri* is distinguished by its tumid shape, narrow interarea, rounded to obtusely subangular cardinal extremities, and rather small size. All specimens from Cherry Creek, the type locality of this species, have only three plications in the sulcus in the pedicle valve.

*Anthracospirifer breckenridgensis* (Weller) somewhat resembles this species in having a similar shell, subcircular in outline, bearing a short interarea and obtusely subangular cardinal extremities. Examination of a large suite of specimens from a shale bed in the Gasper Oolite in Breckenridge County, Ky., in the U.S. Geological Survey collection, indicates that shells similar to Weller's types intergrade with

somewhat wider forms, including even somewhat alate specimens, all apparently belonging to the same population. Although related to *A. welleri* in a general way, *A. breckenridgensis* differs (besides intergrading with wider shells having acute cardinal extremities) in having lower and generally fewer rounded plications (of which normally seven to nine occur on each lateral slope), a more elevated and slightly narrower fold in the brachial valve, a steeper interarea in the pedicle valve, and more prominent growth lamellae anteriorly on both valves.

Intergradation between *A. welleri* and *A. shawi* has not been noted. *A. shawi* differs in having a more transverse shell with acute or subacute cardinal extremities, a more elevated and slightly narrower fold in the brachial valve, and generally wider and more prominent costae.

*Types.*—Lectotype and two paralectotypes, UM 3532; hypotype, UW IT-201. Holotype of *Rhipidomella gregeri* C. Branson, UM 6586; paratypes UM 6593, 6602, 6613.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 21 (6), 22 (14), 26b (70), 27 (3), 28 (10), 29 (3), 30 (9), 31 (9), 36a (38+ fragments), 36b (lectotype and two paralectotypes of *A. welleri*), 36d (holotype and 11 paratypes of *R. gregeri*), 39 (4), B (8), E (1), Fremont County.

*Anthracospirifer welleri lincolniensis* n. subsp.

Plate 13, figures 1-7

*Diagnosis.*—Moderately narrow medium-sized *Anthracospirifer* normally having 29 or 31 costae on pedicle valve, some of them increasing by bifurcation; cardinal extremities subrectangular to submucronate; umbonal region solid, filled with secondary calcareous material

*Description.*—Shell moderately tumid, both valves equally convex, transverse to elongate oval in outline, submucronate; greatest width at or near hinge line; lateral margins fairly straight to sigmoidal, greatest convexity near beak, which is moderately incurved, and lessening anteriorly. Interarea rather low to moderately high, concave in profile view. Median sulcus well defined, concave in cross section, beginning at umbo and extending to anterior margin but shallowing anteriorly, forming short anteriorly produced lingua that protrudes into fold of brachial valve. Surface of valve bearing rounded costae separated by slightly narrow intercostal furrows; normally 5 costae are present within sulcus and 12 or 13 on each lateral slope. Costae on inner part of lateral slopes tend to bifurcate, those bordering sulcus dividing

near beak or near middle of shell toward outer side; third and fourth primary costae commonly dividing on inner side. Shell rather thick; interior of pedicle valve filled with secondary calcareous deposit, particularly in umbonal part surrounding short narrow dental plates.

Brachial valve about as deep as pedicle valve; greatest convexity approximately in middle of valve in both lateral and transverse profiles. Fold bordered by prominent furrows. Costae like those in pedicle valve, having normally 6 on fold and 11 or 12 on each lateral slope, the one at either side of fold normally bifurcated. Brachial valve interior not observed.

*Dimensions.*—Holotype measures (in mm); length, 18.5; width near middle of shell, 21; width at hinge, 20; and thickness (both valves) 13.5. Gerontic specimens commonly are longer than wide, a large pedicle valve from the same locality as the holotype measuring (in mm): length, 28; width near middle, 24; width at hinge, 20; and depth 12.

*Discussion.*—Despite the relative abundance of the material, none of the shells is well preserved. The holotype is a typical complete, but somewhat eroded shell. At its type locality in the Salt River Range, *A. welleri lincolnensis* occurs in the Ranchester Limestone Member in association with rare specimens of a moderately alate *anthracospirifer* referred to *A. shawi exoletus*.

At Berry Creek in the Teton Range, *A. w. lincolnensis* occurs in limestone lenses in reddish-gray shale of the Horseshoe Shale Member. Surfaces of some of the shells are fairly well preserved and show the typical micro-ornament of intersecting radial and concentric lirations. The costae are well rounded, the intercostal furrows decidedly narrow, and the tendency toward bifurcation of the costae less than at the type locality. No example of this species has been found in the shale beds, which are crowded with shells of *Anthracospirifer* aff. *A. occiduus* (Sadlick), form A. This facies control of the *anthracospirifers* is striking.

*Comparisons and affinities.*—This species is somewhat variable, both in shape and sculpture. Specimens have been observed having three, five, or seven costae in the sulcus, but the two extremes are rare. Some small specimens having three costae in the sulcus also have rounded cardinal extremities and thus do not differ materially from *A. welleri welleri*. This is believed to indicate a derivation of *A. w. lincolnensis* from *A. w. welleri*. For this reason it is considered a subspecies of *A. welleri*, rather than a distinct species.

Typical *A. w. lincolnensis* differs from *A. w. wel-*

*leri* in having subrectangular to submucronate cardinal extremities in the adult shell, in generally having two more costae in the sulcus, on the fold, and on each lateral slope than are found in *A. w. welleri*, and in the bifurcation of certain of the costae. Although it resembles *A. w. welleri* somewhat in its narrow shape, *A. w. lincolnensis* develops a pattern of costation somewhat like that of *A. occiduus*.

*A. birdspringensis* Lane, the type species of *Anthracospirifer*, is similar in some respects to *A. welleri lincolnensis*. The maximum number of its costae is the same as the normal number of costae in *A. w. lincolnensis*, and the costae bifurcate in roughly the same manner. The normal number of costae in *A. birdspringensis* is less than in *A. w. lincolnensis* and may be as few as three in the sulcus and seven on each lateral slope. The shell of *A. birdspringensis* is more transverse and the costae narrower and intercostal furrows wider than in *A. w. lincolnensis*.

*Types.*—Holotype, USNM 167759; paratypes, USNM 168459, 174031.

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 149 (36), 153 (4), 154 (50), Teton County. Ranchester Limestone Member: collections 82 (65), 96 (3), 97 (11), 98 (2), Lincoln County.

#### Genus BRACHYTHYRINA Fredericks, 1929

*Brachythyryna washakiensis* n. sp.

Plate 13, figures 8–13

*Diagnosis.*—Medium-sized transverse spiriferoid resembling *Anthracospirifer increbescens* (Hall) in outline, but having costae of very low convexity separated by narrow grooves, as in *Brachythyris*, of which 35 to 37 occur on pedicle valve. Micro-ornament of fine concentric lirae without radial elements.

*Description.*—Pedicle valve wider than long, greatest width along hinge; cardinal extremities generally extended as sharp points; moderately convex in side view, greatest convexity near posterior end, becoming slightly less convex near anterior end; beak moderately incurved; convexity moderate to low in posterior view. Interarea wide, extending to extremities of hinge, strongly concave posteriorly to nearly flat anteriorly, longitudinally grooved, minutely toothed along anterior edge; triangular delthyrium slightly wider than high, each side bordered internally by shallow dental ridge terminating in hinge tooth. Median sulcus beginning 2 or 3 mm in front of beak and extending to anterior margin, broadly V-shaped in middle of valve, becoming gently concave toward anterior margin, its lateral boundaries poorly delimited.

Surface sculpture consisting of low gently rounded costae separated by very narrow grooves. Five costae in sulcus on all pedicle valves of type lot, middle one either narrower or slightly wider than strong adjacent pair; outer pair always narrow, weakly split from broad costa at either side of sulcus. Costae on lateral slopes become lower, narrower, and weaker toward cardinal extremities, where they are difficult to distinguish; 15 or 16 is usual number on lateral slopes.

Brachial valve less convex than pedicle one, its greatest convexity slightly posterior to middle of valve. Fold not clearly defined at beak, but begins 2 to 3 mm in front of it, extending to anterior margin; fold low, moderately broad, and not markedly set off by flanking grooves. Surface ornamentation similar to that of pedicle valve; six costae occur on fold.

*Dimensions*.—Two pedicle valves (holotype and paratype): length 25 (estimated) and 20, width 37.5 and 35 (estimated), depth 10.0 and 9.5 mm, respectively.

*Discussion*.—This species is based on five pedicle valves and one brachial valve, all of them incomplete. These have the surface partly silicified; they have the main characters of the species, and the species is distinctive enough to be rather easily identified and not readily confused with any other spiriferoid in the Amsden of Wyoming. Microornament can be seen on some of the surfaces and also in a small fragment of external mold from one of the specimens.

Bifurcation of the costae is rare on the lateral slopes in most of these specimens and is difficult to see because of the weakness of the costae, but, where present, generally affects those that are not far from the edge of the sulcus. In one paratype (USNM 167761) the fourth and fifth costae from the edge of the sulcus at either side are bifurcated anteriorly. This specimen (pl. 13, fig. 12) has a strong concentric growth constriction 4 mm from the anterior margin, along which line all the costae in the sulcus bifurcate, so that between this constriction and the anterior margin, 10 costae are present in the sulcus.

Assignment of this species to *Brachythyridina* is based upon the shape of the costae and absence of capillate micro-ornament, which show that it is not an *Anthracospirifer*, and the wide hinge line and pointed cardinal extremities, which are not in accord with an assignment to *Brachythyris* or one of its allied genera. The transverse shape and concentrically lirate to lamellose micro-ornament are typical of *Brachythyridina*.

*Types*.—Holotype USNM 167760, paratypes USNM 167761–167763 (5 paratypes).

*Occurrence and number of specimens*.—Horseshoe Shale Member: collection 41 (6), Teton County.

Genus NEOSPIRIFER Fredericks, 1924

*Neospirifer praenuntius* Easton

Plate 13, figure 14

*Neospirifer praenuntius* Easton, 1962, p. 71, 72, pl. 9, figs. 24, 25.

*Spirifer shoshonensis* Branson and Greger. Easton, 1962 [part], p. 70 [not pl. 9, figs. 21, 22].

This species is represented in our Amsden collections by a single fragment. It consists of the posterior part of the ventral surface of a pedicle valve, showing the median sulcus occupied by five costellae, the middle one separated slightly by a narrow interspace from the two costellae at either side. Two fascicles of costellae are present on the lateral slopes at either side of the sulcus, separated from one another by rather deep rounded grooves. The fragment is 9 mm long and 10 mm wide. The identification of this specimen is based upon direct comparison with Easton's type material from the Heath Formation of Montana.

Easton (1962, p. 70, 72) listed both *Spirifer shoshonensis* and *Neospirifer praenuntius* from USGS locality 13370-PC in the Heath Formation. His specimens from that locality are labeled *S. shoshonensis*. In my opinion, further discussed elsewhere in this paper under *Anthracospirifer curvilateralis* Easton, true *S. shoshonensis* does not occur in the Big Snowy and Amsden Groups in central Montana. Easton's specimens from locality 13370-PC, so labeled, should be referred to *Neospirifer praenuntius* and in part to *Anthracospirifer curvilateralis*, which also occurs at that locality.

*Figured specimen*.—USNM 167764.

*Occurrence*.—Moffat Trail Limestone Member: collection 120, Teton County.

Superfamily SPIRIFERINACEA

Family SPIRIFERINIDAE Davidson

Genus RETICULARIINA Fredericks, 1916

*Reticulariina browni* (Branson and Greger)

Plate 13, figures 23, 24, 30–46

*Spiriferina browni* Branson and Greger, 1918, p. 316, 317, pl. 18, figs. 15, 17.

*Composita blackwelderi* C. Branson, 1937, p. 657, pl. 89, figs. 18–20.

*Reticulariina spinosa* (Norwood and Pratten). Easton, 1962 [part], p. 83–85 [not pl. 10, figs. 12–16].

*Diagnosis*.—Spiriferinid with six to seven rounded plications at either side of fold and sulcus in mature shell; surface covered by numerous tiny spines.

*Description*.—Shell punctate, moderately small,



wider than long; cardinal extremities rounded, greatest width a little anterior to hinge. Lateral slopes on both valves ornamented by six to seven rounded to rarely subangular plications with narrower interspaces, crossed near anterior margin by a few chevronlike growth lamellae.

Pedicle valve strongly convex, greatest curvature in umbonal region; interarea moderately high, concave, subtriangular, well delimited from umbonal slopes by angular margins which diverge from beak at an angle of 120°; sides of delthyrium diverging at angle of 45°. Median sulcus prominent, having steeply sloping sides and moderately broad shallowly concave bottom commonly occupied by low costa in adult shells. Surface spines small, closely spaced,

but two to three times further apart than punctae, most prominent in sulcus and in furrows between plications. Interior of pedicle valve with pair of dental plates that extend about one-quarter length of valve and strong median septum reaching to approximate middle of valve.

Brachial valve less convex than pedicle valve and slightly shallower, greatest curvature in umbonal region, greatest depth at anterior end of fold. Fold well defined with steep sides and gently rounded to nearly flat top delimited from sides by subparallel subangulations. Interarea very low, almost linear. Surface spines present but generally difficult to see on mature specimens. Interior of mature brachial valve not known.

*Dimensions (in mm).—*

|   | USNM<br>168442 | USNM<br>168443    | USNM<br>168444 | USNM<br>168445 | UM<br>6584 |
|---|----------------|-------------------|----------------|----------------|------------|
| Length -----                              | 15.5           | 12.5              | 4.5            | 3.5            | 1.6        |
| Maximum width -----                       | 18.3           | <sup>1</sup> 16.4 | 4.7            | 4.9            | 1.9        |
| Width of hinge -----                      | 15.2           | 9.0               | 3.7            | 4.0            | 0.5        |
| Thickness -----                           | 11.5           | 9.0               | —              | —              | 1.0        |
| Depth of pedicle valve -----              | 9.0            | 7.0               | 2.2            | —              | —          |
| Depth of brachial valve -----             | 6.5            | 4.5               | —              | 1.8            | —          |
| Height of interarea (pedicle valve) ----- | 3.0            | 2.7               | 1.1            | —              | —          |

<sup>1</sup> Twice the half width.

*Discussion.*—Three syntypes are in the University of Missouri collections of which one (UM 2656) figured by Branson and Greger (1918, pl. 19, fig. 15) and in the present report on plate 13, figures 32–36 and 43 is hereby designated the lectotype. The other two specimens are designated paralectotypes. These include one (UM 2650) figured by Branson and Greger (1918, pl. 18, fig. 17) and another unfigured specimen under the same UM number, ground down on the pedicle-valve side to show the median septum and dental plates.

The early neanic stage of this species was described and figured by C. C. Branson (1937) under the name "*Composita blackwelderi* n. sp." A re-examination of Branson's cotypes (syntypes) of *C. blackwelderi* has disclosed the presence of punctate shell structure and small spines scattered over the surface. The punctae and spine bases can be seen particularly well on a syntype (UM 6584) figured by Branson (1937, p. 98, fig. 18) and hereby designated as lectotype of *C. blackwelderi*. All of Branson's types of "*Composita blackwelderi*" are juvenile specimens of *Reticulariina browni*.

In this stage, at shell lengths of 1.3 to 1.6 mm, the fold and sulcus are well developed, along with the pair of plications that border the sulcus. The next plication on each lateral slope of the pedicle valve is just beginning and barely perceptible. On

the brachial valve the plications at either side of the fold begin before the fold, resulting in an ornamentation that consists of a small triangle (the fold) in front of a chevron (the diverging plications). The spines are very small and scattered over both valves.

The late neanic state has been observed in silicified specimens (pl. 13, figs. 23, 24), from the bluffs of Bighorn Canyon opposite Devils Canyon, just across the State border in Montana. At shell lengths of 4.0 and 4.5 mm the pedicle valve is subcircular to suboval, ornamented by four or five low rounded plications on each lateral slope, some specimens with a faint costella occupying the middle of the sulcus. The interior of the pedicle valve bears a pair of short dental plates that reach nearly one-quarter of the way forward from the beak, connecting the inside of the two plications that border the sulcus with the sides of the delthyrium. Between these, a low narrow median ridge extends forward from the beak one-third to two-fifths of the distance from beak to anterior margin.

The brachial valve is transversely oval in outline, not quite as deep as the pedicle valve but slightly more convex, broadly arched in anterior profile. The median fold is broad and rounded, slightly flattened on top anteriorly, some specimens having a faint median groove; three or four low rounded plications,

separated by slightly narrower rounded grooves, occupying each lateral slope.

Internally the brachial valve cardinalia consist of a diverging pair of inner and outer socket ridges at either side of a tiny triangular cardinal process, enclosing a socket at the distal end of each. Attached to the inner socket plates and slightly dorsad and anterior to each are a pair of triangular crural bases from which the crura extend almost parallel to the floor of the valve. Details of the spiralia are not preserved.

Surfaces of both valves bear short tiny spines, directed anteriorly or radially, scattered randomly over the posterior part of the valves but tending to form fringelike rows along or between thin irregular concentric lamellae along and near the anterior margin.

*Comparisons and affinities.*—The classification of this species as a *Reticulariina* has been given careful consideration because the surface spines are so tiny that Branson and Greger (1918, p. 317) believed that none were present. Examination under the binocular microscope has shown that these little spines are hollow and are not like the granules that cover the surface of the shell in the allied genus *Spiriferellina*.

Among the American Mississippian species formerly classified loosely as "*Spiriferina*" and including those shells with smooth to spinose surfaces are the following:

1. Surface smooth, partly to entirely covered by fine granules: *Spiriferina spinosa* var. *campestris* White, *S. salemensis* Weller, *S. subspinosa* Weller, and *Spiriferellina lata* Lane.
2. Surface covered with pustules: *Spiriferina spinosa* var. *cochisensis* Hernon.
3. Surface covered with small spines: *Spirifer spinosus* Norwood and Pratten, *S. norwoodanus* Hall, *Spiriferina gonionota* Meek, and *S. browni* Branson and Greger.

*Reticulariina spinosa* (Norwood and Pratten) differs from *R. browni* in having fewer plications (four or five on each lateral slope), a narrower and more rounded fold and sulcus, and coarse surface spines that are much more widely spaced than the tiny spines of *R. browni*.

*R. gonionota* (Meek) also has fewer plications (three to five on each lateral slope in Great Basin specimens), the fold is more prominent than in either *R. spinosa* or *R. browni*, and the spines are somewhat smaller than in *R. spinosa* but considerably larger than those of *R. browni* and sparser than in the other two species.

*Reticulariina norwoodana* (Hall) is the smallest of the North American reticulariinas, having three to five low rounded plications, a narrow shallow sulcus in the pedicle valve, and low fold in the brachial valve. Tiny spines, but fairly large in proportion to the shell, are scattered over the surface. Although Weller (1914, p. 296) referred to these as papillae, specimens from the Salem Limestone at Stinesville, Ind., in the U.S. Geological Survey collections show that these are actually anteriorly directed short hollow spines. Its small size, fewer spines, narrower and less prominent fold and sulcus, and fewer and less elevated plications distinguish this species without difficulty from *R. browni*.

*Reticulariina browni* is restricted to the *Carlinia amsdeniana* Subzone in Fremont County, Wyo. At a locality just across the State border, in Carbon County, Mont., this species was found with fossils typical of the *Composita poposiensis* Subzone, but lacking *C. poposiensis*.

*Types.*—Lectotype, UM 2656; paralectotypes, UM 2650 (two specimens); hypotypes, USNM 168442–168445 (four specimens); of *Composita blackwelderi* C. Branson: lectotype, UM 6584 (part); paralectotypes, UM 5683, 6584 (three specimens).

*Occurrence and number of specimens.*—Horseshoe Shale Member: collections 26b (23), 27 (21), 36a (21 + fragments), 36b (lectotype), 36c (2 paralectotypes), 36d (5), A (1), B (3), E (3), Fremont County, Wyo., collection 69 (11), Carbon County, Mont.

Suborder RETZIIDINA  
Superfamily RETZIACEA Waagen  
Family RETZIIDAE Waagen  
Genus EUMETRIA Hall, 1864

*Eumetria sulcata* Burk

Plate 13, figures 19, 20, 25–29

*Eumetria verneuiliana* (Hall). Branson and Greger, 1918, p. 320, pl. 18, figs. 20, 21.

*Eumetria sulcata* Burk, 1954, p. 14, pl. 1, figs. 31–34.

*Diagnosis.*—*Eumetria* having 35 to 43 costae in pedicle valve and 36 to 42 in brachial valve; costae low, rounded, and separated by very narrow intercostal grooves. Shallow broad median sulcus present in pedicle valve in some specimens.

*Dimensions (in mm).*—

|                    | USNM<br>168446 | UW<br>1T-231 | UM<br>2653        | USNM<br>168447 |
|--------------------|----------------|--------------|-------------------|----------------|
| Length -----       | 22.7           | 17.3         | <sup>1</sup> 13.5 | 12.8           |
| Width -----        | 21.8           | 14.5         | 13.5              | 12.3           |
| Width of hinge --- | ?              | 4.0          | 4.8               | 3.2            |
| Thickness -----    | 11.7           | 9.2          | 8.3               | 6.9            |

<sup>1</sup> Small fragment broken off at anterior margin, necessitating estimate.

*Discussion.*—In this species, each valve has approximately 38 costae. The shape of the shell and

prominence of the sulcus have a considerable range of variation. More elongate specimens with deeper valves are more likely to develop a sulcus. Broader shells of subequal length and width are commonly shallower and without a well-defined sulcus.

Included in the table above is a specimen (UM 2653) figured by Branson and Greger (1918, pl. 18, fig. 21) as *E. verneuilliana* (Hall). Branson and Greger's figured specimens are from Cherry Creek; they are silicified and presumably are from the *Composita poposiensis* Subzone. They are regarded as topotypes of *Eumetria sulcata* Burk.

Also belonging in this species are specimens identified by Shaw and Bell (1955, p. 335, fig. 1) as *E. verneuilliana*, preserved in calcareous sandstone and coming from the *Carlinia amsdeniana* Subzone at Cherry Creek. The broad low costae on these specimens, of which less than 45 are normally present on each shell, show that they cannot be assigned to *E. verneuilliana*, which has narrow raised subrounded to subacute costae and moderately broad intercostal sulci, generally more than 50 on each valve.

*Eumetria sulcata*, as pointed out by Burk (1954, p. 14), is close to *E. costata* (Hall). One might even consider it a subspecies of *E. costata* because the number of its costae falls within the range of Hall's species—30 to 42. However, typical *E. costata*, although similar in shape to some specimens of *E. sulcata*, normally has a slightly narrower, larger, and more tumid shell in which the pedicle valve is invariably convex near the anterior margin, showing no sign of a sulcus. Typical *E. costata*, moreover, has fewer than 35 costae on each valve. It seems reasonable, therefore, to consider *E. sulcata* a valid species.

**Types.**—Holotype, UW IT-231; hypotypes UM 2653, USNM 168457, 168458; additional measured specimens, USNM 168446, 168447.

**Occurrence and number of specimens.**—Horseshoe Shale Member: collections 26b (3), 27 (3), 28 (6), 29 (6), 30 (6), 31 (6), 32 (5), 35 (7), 36a (9), 36e (1), 38 (9), 39 (1), B (3), D (1), Fremont County, Wyo.; 69 (2), Carbon County, Mont. Ranchester Limestone Member: collection 146 (8), Teton County, Wyo.

Order TEREBRATULIDA  
Suborder TEREBRATULIDINA  
Superfamily DIELASMATACEA  
Family CRANAENIDAE Cloud  
Genus GIRTYELLA Weller, 1911

*Girtyella* cf. *G. indianensis* (Girty)

Plate 13, figures 15–18, 21, 22

?*Girtyella indianensis* (Girty). C. Branson, 1937, p. 657.

A fairly complete specimen (UM 10890) collected

by C. C. Branson from the Little Popo Agie River area is apparently the one upon which the record cited above was based. The calcareous preservation and limonite adhering to this shell indicates that it comes from the *Carlinia amsdeniana* Subzone. Figured here on plate 13, figures 15–18, it measures (in mm): length 13.5, width (twice the half width) 11.2, and thickness 6.5. The greatest thickness occurs about one-third of the way forward in the brachial valve and near the middle of the pedicle valve; greatest width is at the middle of the shell. Part of one side is missing, and some distortion in the anterior part of the shell has obscured the details of the sulcus and fold. The sulcus begins near the middle of the pedicle valve and is moderately prominent. The curved beak is well defined and nearly erect at the tip. A short median septum is visible in the apical part of the brachial valve. Shell structure is punctate.

A brachial valve preserved in calcareous sandstone also belongs in this genus. It was collected in place by W. G. Bell from the *Carlinia amsdeniana* Subzone at Cherry Creek. The valve is broadly oval, its length 10.5, width 9.2, and depth 2.0 mm, with a very narrow strip of the anterior edge missing. At the anterior end, an incipient median sulcus and a pair of faint lateral sulci delimiting between them a pair of small folds are very weakly developed. A median septum 4 mm long extends from the umbo. The shell is minutely punctate.

Also included here tentatively is one of the paratypes (UM 6585) of *Rhipidomella gregeri* C. Branson. This tiny shell has the shape of a young *Girtyella* or *Cranaena* and has a finely punctate shell structure. It measures 1.5 mm long and 1.3 mm wide. A narrow shallow sulcus is present in the pedicle valve. The internal characters, however, could not be ascertained.

The characters of the two larger shells are close to those of *G. indianensis* (Girty), and all three could belong to this or a closely allied form.

**Figured specimens.**—UM 10890, UW A11118.

**Mentioned specimen.**—UM 6585.

**Occurrence and number of specimens.**—Horseshoe Shale Member: collections 28 (1), 36d (2), Fremont County.

Incertae sedis  
Genus SELENELLA Hall and Clarke, 1894

*Selenella? walteri* (C. Branson)

*Selenella? walteri* C. Branson, 1937 [part], p. 657, pl. 89, fig. 21 [not fig. 22.].

Among the tiny juvenile shells illustrated by C. C. Branson (1937) were three specimens assigned with question to *Selenella*. Two of these, the para-

types, are subtriangular in shape and interpreted here as probably juvenile examples of *Pugnoides quinqueplecis* Easton. The holotype, however, is elongate-oval and is not recognized as a rhynchonellid. Until fairly complete growth suites become available, it does not seem possible to connect *S. ? walteri* with any adult form. The name, now restricted to the holotype, is regarded as belonging to a species inquirenda.

*Type*.—Holotype, UM 6581.

*Occurrence*.—Horseshoe Shale Member: collection 36b, Fremont County.

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# INDEX

[Italic page numbers indicate both major references and descriptions]

| A   | Page  |
|---|---|
| Acrotretida   | D21   |
| Acrotretidina   | 21  |
| ( <i>Actinocyathus</i> ) <i>stelcki</i> , <i>Lonsdaleia</i> | 15  |
| <i>adonis</i> , <i>Spirifer</i>                             | 70  |
| <i>alternatus</i> , <i>Echinoconchus</i>                    | 43, 44  |
| <i>altirostris</i> , <i>Schizophoria</i>                    | 23  |
| <i>amsdenensis</i> , <i>Barytichisma</i>                    | 15  |
| <i>Meekella</i>   | 2, 24   |
| <i>Multithecopora</i>                                       | 15  |
| <i>Orthotetina</i>  | 2, 6, 12, 15, 16, 19, 24, 27, 28; pl. 2         |
| <i>amsdeniana</i> , <i>Carlinia</i>                         | 2, 3, 6, 12, 15, 16, 19, 42, 45; pl. 4          |
| <i>Carlinia</i> Subzone                                     | 16, 17, 18, 21, 22, 62, 71, 77, 78              |
| Analysis of faunal relationships                            | 15  |
| <i>Anthracospirifer</i>                                     | 5, 13, 15, 65, 66                               |
| <i>birdsringensis</i>                                       | 74  |
| <i>breckenridgensis</i>                                     | 73  |
| <i>curvilateralis</i>                                       | 15, 19, 66, 68, 75                              |
| <i>brutus</i>   | 6, 11, 15, 17, 66; pl. 11                       |
| <i>curvilateralis</i>                                       | 6, 11, 17, 65; pl. 11                           |
| <i>increbescens</i>   | 65, 66, 74                                      |
| <i>leidy</i>  | 72  |
| <i>matheri</i>  | 68  |
| <i>occiduus</i>   | 6, 12, 13, 14, 15, 17, 20, 67, 73, 74; pl. 11   |
| form A  | 68; pl. 11                                      |
| form B  | 69; pl. 11                                      |
| <i>opimus</i>   | 68, 72  |
| <i>pellensis</i>  | 72  |
| <i>rawlinsensis</i>   | 6, 13, 15, 17, 69; pl. 11                       |
| <i>rockymontanus</i>  | 68  |
| <i>shawi</i>  | 17, 19, 72, 73                                  |
| <i>exoletus</i>   | 2, 3, 6, 12, 13, 14, 15, 17, 71, 72, 74; pl. 12 |
| <i>shawi</i>  | 2, 6, 12, 15, 17, 70, 71; pl. 12                |
| <i>shoshonensis</i>   | 65, 70  |
| <i>welleri</i>  | 17, 19, 73, 74                                  |
| <i>lincolnensis</i>   | 6, 12, 13, 15, 17, 73; pl. 13                   |
| <i>shawi</i> Zone   | 16, 17, 19, 20                                  |
| <i>welleri</i>  | 2, 3, 6, 12, 15, 17, 60, 71, 72, 74; pl. 12     |
| sp  | 6, 14   |
| <i>Antiquatonia</i>   | 5, 16, 46, 49                                   |
| <i>antiquatus</i>   | 48  |
| <i>blackwelderi</i>   | 6, 13, 14, 15, 16, 20, 46; pl. 5                |
| Zone  | 16  |
| <i>coloradoensis</i>  | 6, 13, 14, 15, 16, 20, 47; pl. 5                |
| <i>hermosana</i>  | 47  |
| <i>pernodosa</i>  | 47, 48, 49, 52                                  |
| sp  | 6, 11, 15, 49                                   |
| <i>antiquatus</i> , <i>Antiquatonia</i>                     | 48  |
| <i>arizonensis</i> , <i>Buxtonia</i>                        | 47, 48  |
| <i>Articulata</i>   | 22  |
| <i>Athyridacea</i>  | 55  |
| <i>Athyrididae</i>  | 5, 54   |
| <i>Athyrididina</i>   | 55  |
| <i>Athyrids</i>   | 16  |
| <i>Athyris subquadrata</i>                                  | 59  |
| <i>atrypoides</i> , <i>Cleiothyridina</i>                   | 55, 56, 57                                      |

|  | Page   |
|--|--|
| <i>saginata</i> , <i>Cleiothyridina</i>                        | D6, 11, 12, 15, 17, 55; pl. 7                  |
| B  |  |
| <i>Barytichisma amsdenensis</i>                                | 15   |
| <i>bilobata</i> , <i>Inflatia</i>                              | 37   |
| <i>birdsringensis</i> , <i>Anthracospirifer</i>                | 74   |
| <i>blackwelderi</i> , <i>Antiquatonia</i>                      | 6, 13, 14, 15, 16, 20, 46; pl. 5               |
| <i>Antiquatonia</i> Zone                                       | 16   |
| <i>Composita</i>   | 1, 2, 75, 76, 77                               |
| <i>boonensis</i> , <i>Cancrinella</i>                          | 3, 49  |
| <i>Spirifer</i>  | 67   |
| <i>Brachiopoda</i>   | 20   |
| <i>Brachiopods</i> , geographic and stratigraphic distribution | 5  |
| zonal distribution   | 14   |
| <i>Brachythyridina</i>   | 1, 5, 74, 75                                   |
| <i>washakiensis</i>  | 6, 11, 12, 15, 17, 74; pl. 13                  |
| <i>Brachythyris</i>  | 74, 75   |
| <i>bransonorum</i> , <i>Orthotetes</i>                         |  |
| <i>kaskaskiensis</i>   | 2, 3, 6, 11, 12, 15, 16, 29, 30, 31; pls. 1, 2 |
| <i>breckenridgensis</i> , <i>Anthracospirifer</i>              | 73   |
| <i>browni</i> , <i>Reticulariina</i>                           | 2, 3, 6, 12, 13, 15, 18, 19, 75; pl. 13        |
| <i>Spiriferina</i>   | 2, 75, 77                                      |
| <i>brutus</i> , <i>Anthracospirifer</i>                        |  |
| <i>curvilateralis</i>  | 6, 11, 15, 17, 66; pl. 11                      |
| <i>Buxtonia arizonensis</i>                                    | 47, 48   |
| <i>Buxtoniidae</i>   | 5, 44  |
| C  |  |
| <i>campestris</i> , <i>Spiriferina spinosa</i>                 | 3, 77  |
| <i>Cancrinella boonensis</i>                                   | 3, 49  |
| <i>Caninia nevadensis</i>                                      | 15   |
| <i>sublamellosa</i>  | 17   |
| Zone   | 11, 12, 16, 17, 19, 43                         |
| <i>carbonaria</i> , <i>Lingula</i>                             | 4, 6, 12, 14, 16, 20                           |
| <i>Orthis</i>  | 23   |
| <i>Rhipidomella</i>  | 6, 13, 15, 16, 23; pl. 1                       |
| <i>Carlinia</i>  | 5, 16, 42                                      |
| <i>amsdeniana</i>  | 2, 3, 6, 12, 15, 16, 19, 42, 45; pl. 4         |
| Subzone  | 16, 17, 18, 21, 22, 62, 71, 77, 78             |
| <i>diabolica</i>   | 42   |
| <i>elegans</i>   | 17   |
| <i>phillipsi</i>   | 43   |
| <i>cestriensis</i> , <i>Diaphragmus</i>                        | 6, 11, 15, 16, 19, 39, 41, 50, 54, 55; pl. 4   |
| <i>Productus</i>   | 39   |
| <i>Chaetetes wyomingensis</i>                                  | 15   |
| <i>chesterensis</i> , <i>Chonetes</i>                          | 2  |
| <i>Chonetacea</i>  | 32   |
| <i>Chonetes</i>  | 33   |
| <i>chesterensis</i>  | 2  |
| <i>choteauensis</i>  | 33   |
| <i>granulifer</i>  | 33   |
| <i>laevis</i>  | 32, 33   |
| <i>pseudoliratus</i>   | 33   |
| <i>sericius</i>  | 33   |
| <i>suttoni</i>   | 34, 35   |

|   | Page   |
|---|--|
| <i>Chonetidae</i>                               | D5, 32   |
| <i>Chonetidina</i>                              | 32   |
| <i>Chonetids</i>                                | 16   |
| <i>choteauensis</i> , <i>Chonetes</i>           | 33   |
| <i>Cleiothyridina</i>                           | 5, 16, 55  |
| <i>atrypoides</i>                               | 55, 56, 57   |
| <i>saginata</i>                                 | 6, 11, 12, 15, 17, 55; pl. 7                               |
| <i>elegans</i>                                  | 2, 6, 12, 57; pl. 7  |
| <i>hirsuta</i>                                  | 2, 57  |
| <i>darwinensis</i>                              | 3, 12, 15, 17, 56, 57, 58; pl. 7                           |
| <i>orbicularis</i>                              | 57, 58   |
| <i>sublamellosa</i>                             | 6, 11, 56, 57, 58; pl. 7                                   |
| sp  | 3, 6, 13, 14, 56, 57, 58, 61, 62                           |
| <i>cochisensis</i> , <i>Spiriferina spinosa</i> | 77   |
| <i>Coledium</i>                                 | 5, 54  |
| <i>explanatum</i>                               | 55   |
| <i>fragum</i>                                   | 6, 11, 15, 16, 54; pl. 7                                   |
| <i>obesum</i>                                   | 55   |
| <i>rhomboidale</i>                              | 55   |
| <i>coloradoensis</i> , <i>Antiquatonia</i>      | 6, 13, 14, 15, 16, 20, 47; pl. 5                           |
| <i>Dictyoclostus</i>                            | 47   |
| <i>Productus</i>                                | 47   |
| <i>inflatus</i>                                 | 47   |
| <i>Composita</i>                                | 3, 4, 5, 11, 15, 17, 58, 59, 62                            |
| <i>blackwelderi</i>                             | 2, 75, 76, 77  |
| <i>elongata</i>                                 | 6, 13, 14, 15, 17, 64; pl. 10                              |
| <i>farrelli</i>                                 | 58, 59   |
| <i>laevis</i>                                   | 6, 11, 15, 17, 58, 59; pl. 8                               |
| <i>ovata</i>                                    | 6, 13, 14, 15, 17, 20, 60, 63, 64; pl. 10                  |
| <i>ozarkana</i>                                 | 59   |
| <i>poposensis</i>                               | 2, 3, 6, 12, 13, 15, 16, 17, 19, 60, 61, 63, 77; pls. 8, 9 |
| Subzone   | 16, 17, 18, 19, 21, 54, 62, 72, 77, 78                     |
| <i>sigma</i>                                    | 2, 6, 12, 13, 14, 15, 17, 19, 59, 64; pls. 8, 9            |
| <i>subquadrata</i>                              | 6, 11, 12, 15, 17, 19, 58, 59, 63; pls. 8, 9               |
| <i>subtilita</i>                                | 6, 14, 15, 17, 62, 64; pl. 10                              |
| <i>ovata</i>                                    | 3, 61, 62  |
| <i>subtilita</i>                                | 3, 61, 62  |
| <i>trinuclea</i>                                | 3, 61  |
| <i>sulcata</i>                                  | 3, 6, 12, 15, 17, 19, 59, 62; pl. 8                        |
| <i>trinuclea</i>                                | 2, 59, 61, 62  |
| sp  | 3, 6, 11, 12, 13, 14                                       |
| Composition of the fauna                        | 4  |
| <i>confluens</i> , <i>Dictyoclostus</i>         | 39   |
| <i>Inflatia</i>                                 | 37   |
| <i>costata</i> , <i>Eumetria</i>                | 18, 78   |
| <i>Cranaena</i>                                 | 58, 78   |
| <i>Cranaenidae</i>                              | 5, 78  |
| <i>croneisi</i> , <i>Linoproductus</i>          | 2, 49, 50  |
| <i>Ovatia</i>                                   | 2, 3, 6, 12, 15, 49, 51, 52; pl. 6                         |
| <i>curvilateralis</i> , <i>Anthracospirifer</i> | 15, 19, 66, 68, 75   |
| <i>Anthracospirifer</i>                         |  |
| <i>curvilateralis</i>                           | 6, 11, 17, 65; pl. 11                                      |
| <i>brutus</i> , <i>Anthracospirifer</i>         | 6, 11, 15, 17, 66; pl. 11                                  |
| <i>curvilateralis</i> , <i>Anthracospirifer</i> | 6, 11, 17, 65; pl. 11                                      |
| <i>Spirifer</i>                                 | 65   |

|   | Page  |
|---|---|
| <b>D</b>                                      |   |
| Darwin Sandstone Member                       | D5  |
| <i>darwinensis</i> , <i>Cleiothyridina</i>    |   |
| <i>hirsuta</i>                                | 3, 12, 15, 17, 56; pl. 7                        |
| Davidsoniacea                                 | 24  |
| <i>decipiens</i> , <i>Mesolobus mesolobus</i> | 33  |
| <i>delira</i> , <i>Pulsia</i>                 | 6, 14, 15, 16, 26, 27; pl. 2                    |
| <i>depressa</i> , <i>Schizophoria</i>         | 2, 4, 6, 11, 12, 13, 14, 15, 16, 22, 23; pl. 1  |
| <i>Derbyia</i>                                | 5, 25, 27, 30, 31                               |
| <i>robusta</i>                                | 6, 13, 14, 15, 16, 27, 31; pl. 2                |
| ( <i>Derbyia</i> ) sp, <i>Orthotetes</i>      | 30  |
| <i>diabolica</i> , <i>Carlinia</i>            | 42  |
| <i>Diaphragmus</i>                            | 5, 16, 39, 42                                   |
| <i>cestriensis</i>                            | 6, 11, 15, 16, 19, 39, 41, 50, 54, 55; pl. 4    |
| <i>elegans</i>                                | 39  |
| <i>fasciculatus</i>                           | 39, 41  |
| <i>motesanae</i>                              | 39  |
| <i>nivosus</i>                                | 6, 11, 12, 15, 16, 19, 40; pl. 4                |
| <i>phillipsi</i>                              | 2, 42, 45                                       |
| ( <i>Productus</i> ) <i>elegans</i>           | 39  |
| <i>Dictyoclostidae</i>                        | 5, 46   |
| <i>Dictyoclostus coloradoensis</i>            | 47  |
| <i>confluens</i>                              | 39  |
| <i>inflatus</i>                               | 47, 48  |
| <i>portlockianus</i>                          | 3, 36, 37                                       |
| <i>Dielasmatacea</i>                          | 78  |
| <i>Discinacea</i>                             | 21  |
| <i>Discinidae</i>                             | 5, 21   |
| <i>drummondi</i> , <i>Pleurostrophonella</i>  | 15  |
| <i>duncanae</i> , <i>Duncanopora</i>          | 15  |
| <i>Duncanopora duncanae</i>                   | 15  |
| <i>duodenaria</i> , <i>Ovatia</i>             | 50, 51  |
| <b>E</b>                                      |   |
| <i>eastoni</i> , <i>Linoproductus</i>         | 6, 13, 14, 15, 20, 51, 53; pl. 6                |
| <i>Echinoconchidae</i>                        | 5, 43   |
| <i>Echinoconchus</i>                          | 5, 16, 43, 44, 45                               |
| <i>alternatus</i>                             | 43, 44  |
| <i>vittatus</i>                               | 44  |
| sp A  | 6, 13, 14, 15, 43; pl. 3                        |
| <i>elegans</i> , <i>Carlinia</i>              | 17  |
| <i>Cleiothyridina</i>                         | 2, 6, 12, 57; pl. 7                             |
| <i>Diaphragmus</i>                            | 39  |
| ( <i>Productus</i> )                          | 39  |
| <i>Productus</i>                              | 39, 40  |
| <i>elongata</i> , <i>Composita</i>            | 6, 13, 14, 15, 17, 64; pl. 10                   |
| <i>Elythidae</i>                              | 5, 65   |
| <i>Enteletacea</i>                            | 22  |
| <i>Enteletidae</i>                            | 5, 22   |
| <i>Eolissochonetes</i>                        | 5, 32, 33                                       |
| <i>keyesi</i>                                 | 32, 33  |
| <i>pseudoliratus</i>                          | 4, 6, 12, 13, 14, 15, 16, 20, 33, 34, 35; pl. 1 |
| <i>Eolissochonetes suttoni</i>                | 6, 16, 34; pl. 1                                |
| <i>Eumetria</i>                               | 5, 77   |
| <i>costata</i>                                | 18, 78  |
| <i>sulcata</i>                                | 2, 3, 6, 12, 13, 14, 15, 18, 77; pl. 13         |
| <i>vereneuiliana</i>                          | 2, 77, 78                                       |
| sp  | 6, 11   |
| <i>exoletus</i> , <i>Anthracospirifer</i>     |   |
| <i>shawii</i>                                 | 2, 3, 6, 12, 13, 14, 15, 17, 71, 72, 74; pl. 12 |
| <i>explanatum</i> , <i>Coledium</i>           | 55  |
| <b>F</b>                                      |   |
| <i>farrelli</i> , <i>Composita</i>            | 58, 59  |
| <i>fasciculatus</i> , <i>Diaphragmus</i>      | 39, 41  |
| <i>Productus</i>                              | 30, 40, 41                                      |
| Faunal relationships analysis                 | 15  |
| Faunal succession interpretation              | 18  |

|   | Page   |
|---|--|
| <i>Flexaria</i>                               | D5, 16, 44, 45                                 |
| sp  | 2, 6, 12, 15, 44, 45; pl. 3                    |
| Fossil localities                             | 4  |
| <i>fragum</i> , <i>Coledium</i>               | 6, 11, 15, 16, 54; pl. 7                       |
| <b>G</b>                                      |  |
| <i>genevicensis</i> , <i>Pustula</i>          | 2, 42, 44, 45                                  |
| Geographic and stratigraphic distribution     |  |
| of the brachiopods                            | 5  |
| <i>Girtyella</i>                              | 5, 58, 78                                      |
| <i>indianensis</i>                            | 2, 6, 12, 18, 78; pl. 13                       |
| <i>globosa</i> , <i>Horridonia</i>            | 35   |
| <i>Pustula</i>                                | 35   |
| <i>Scolococoncha</i>                          | 6, 14, 15, 20, 35; pl. 3                       |
| <i>gonionota</i> , <i>Reticulariina</i>       | 77   |
| <i>Spiriferina</i>                            | 3, 77  |
| <i>granulifer</i> , <i>Chonetes</i>           | 33   |
| <i>gregeri</i> , <i>Rhipidomella</i>          | 2, 72, 73, 78                                  |
| <b>H</b>                                      |  |
| <i>hamatilis</i> , <i>Neokoninckophyllum</i>  | 13, 15   |
| <i>hermosana</i> , <i>Antiquatonia</i>        | 47   |
| <i>hirsuta</i> , <i>Cleiothyridina</i>        | 2, 57  |
| <i>darwinensis</i> , <i>Cleiothyridina</i>    | 3, 12, 15, 17, 56; pl. 7                       |
| <i>Horridonia globosa</i>                     | 35   |
| Horseshoe Shale Member                        | 11   |
| <b>I</b>                                      |  |
| Inarticulata                                  | 20   |
| Inarticulates                                 | 16   |
| <i>inconstans</i> , <i>Neokoninckophyllum</i> | 13   |
| <i>increbescens</i> , <i>Anthracospirifer</i> | 65, 66, 74                                     |
| <i>Spirifer</i>                               | 65, 66   |
| <i>indianensis</i> , <i>Girtyella</i>         | 2, 6, 12, 18, 78; pl. 13                       |
| <i>Scolococoncha</i>                          | 36   |
| <i>Inflatia</i>                               | 5, 16, 36, 39, 48                              |
| <i>bilobata</i>                               | 37   |
| <i>confluens</i>                              | 37   |
| <i>inflata</i>                                | 37, 39   |
| <i>lovei</i>                                  | 3, 6, 11, 12, 13, 15, 16, 19, 36; pl. 3        |
| <i>obsoleta</i>                               | 37   |
| <i>spinolinearis</i>                          | 37   |
| <i>inflata</i> , <i>Inflatia</i>              | 37, 39   |
| <i>inflatus</i> , <i>Dictyoclostus</i>        | 47, 48   |
| <i>Productus</i>                              | 47   |
| <i>coloradoensis</i> , <i>Productus</i>       | 47   |
| Interpretation of faunal succession           | 18   |
| <b>J</b>                                      |  |
| <i>Juresania</i>                              | 5, 16, 45                                      |
| <i>nebrascensis</i>                           | 45   |
| <i>ovalis</i>                                 | 46   |
| <i>symmetrica</i>                             | 46   |
| sp  | 6, 13, 14, 15, 45; pl. 3                       |
| <b>K</b>                                      |  |
| <i>kaskaskiensis</i> , <i>Orthotetes</i>      | 2, 29  |
| <i>bransonorum</i> , <i>Orthotetes</i>        | 2, 3, 6, 11, 12, 15, 16, 29, 30, 31, pls. 1, 2 |
| <i>keyesi</i> , <i>Eolissochonetes</i>        | 32, 33   |
| <b>L</b>                                      |  |
| <i>laevis</i> , <i>Chonetes</i>               | 32, 33   |
| <i>Composita</i>                              | 6, 11, 15, 17, 58, 59; pl. 8                   |
| <i>lata</i> , <i>Spiriferellina</i>           | 77   |
| <i>leidyi</i> , <i>Anthracospirifer</i>       | 72   |
| <i>lincolnensis</i> , <i>Anthracospirifer</i> |  |
| <i>welleri</i>                                | 6, 12, 13, 15, 17, 73; pl. 13                  |
| <i>Lingula</i>                                | 5, 16, 20                                      |

|   | Page  |
|---|---|
| <i>carbonaria</i>   | D4, 6, 12, 14, 16, 20; pl. 1                  |
| <i>Lingulida</i>  | 20  |
| <i>Lingulidae</i>   | 5, 20, 21                                     |
| <i>Lingulodiscina</i> sp                                  | 3, 21   |
| <i>Linoproductid</i>                                      | 6, 11   |
| <i>Linoproductidae</i>                                    | 5, 49   |
| <i>Linoproductus</i>                                      | 5, 16, 51, 52, 53                             |
| <i>croneisi</i>   | 2, 49, 50                                     |
| <i>eastoni</i>  | 6, 13, 14, 15, 20, 51, 53; pl. 6              |
| <i>nodosus</i>  | 51, 52  |
| <i>planiventralis</i>                                     | 6, 13, 14, 15, 20, 52; pl. 5                  |
| <i>prattenianus</i>                                       | 3, 50, 51                                     |
| <i>Lonsdaleia</i> ( <i>Actinocyathus</i> ) <i>stelcki</i> | 15  |
| <i>lovei</i> , <i>Inflatia</i>                            | 3, 6, 11, 12, 13, 15, 16, 19, 36; pl. 3       |
| <b>M</b>  |   |
| <i>Marginifera muricatina</i>                             | 3, 42, 43                                     |
| sp  | 3   |
| <i>Marginiferidae</i>                                     | 5, 16, 36                                     |
| <i>Martinia</i>   | 2, 59, 60                                     |
| <i>matheri</i> , <i>Anthracospirifer</i>                  | 68  |
| <i>Meckella</i>   | 26  |
| <i>amsdenensis</i>  | 2, 24   |
| <i>striaticostata</i>                                     | 25  |
| <i>Meckellidae</i>  | 5, 16, 24                                     |
| <i>Mesolobus</i>  | 5, 14, 16, 33, 35                             |
| <i>mesolobus</i>  | 33, 35  |
| <i>mesolobus decipiens</i>                                | 33  |
| sp  | 6, 14, 15, 35; pl. 1                          |
| <i>mesolobus</i> , <i>Mesolobus</i>                       | 33, 35  |
| <i>decipiens</i> , <i>Mesolobus</i>                       | 33  |
| Mississippian and Pennsylvanian                           |   |
| boundary relations  | 4   |
| Moffat Trail Limestone Member                             | 5   |
| <i>mosquensis</i> , <i>Pulsia</i>                         | 26  |
| <i>motesanae</i> , <i>Diaphragmus</i>                     | 39  |
| <i>Multithecopora amsdenensis</i>                         | 15  |
| <i>muralis</i> , <i>Ovatia</i>                            | 3, 6, 11, 12, 15, 50; 52; pl. 6               |
| <i>muricatina</i> , <i>Marginifera</i>                    | 3, 42, 43                                     |
| <b>N</b>  |   |
| <i>nebrascensis</i> , <i>Juresania</i>                    | 45  |
| <i>Neochonetes</i>  | 33  |
| <i>Neokoninckophyllum hamatilis</i>                       | 13, 15  |
| <i>hamatilis</i> Zone                                     | 16  |
| <i>inconstans</i>   | 13  |
| <i>Neospirifer</i>  | 5, 75   |
| <i>praenuntius</i>  | 6, 11, 15, 17, 75; pl. 13                     |
| <i>nevadensis</i> , <i>Caninia</i>                        | 15  |
| <i>nivalis</i> , <i>Rugoclostus</i>                       | 37, 39, 43, 44                                |
| <i>nivosus</i> , <i>Diaphragmus</i>                       | 6, 11, 12, 15, 16, 19, 40; pl. 4              |
| <i>nodosus</i> , <i>Linoproductus</i>                     | 51, 52  |
| <i>norwoodana</i> , <i>Reticulariina</i>                  | 77  |
| <i>norwoodanus</i> , <i>Spirifer</i>                      | 77  |
| <b>O</b>  |   |
| <i>obesum</i> , <i>Coledium</i>                           | 55  |
| <i>obsoleta</i> , <i>Inflatia</i>                         | 37  |
| <i>occidentalis</i> , <i>Spirifer</i>                     | 67  |
| <i>Spirifer optimus</i>                                   | 67  |
| <i>occiduus</i> , <i>Anthracospirifer</i>                 | 6, 12, 13, 14, 15, 17, 20, 67, 73, 74; pl. 11 |
| form A, <i>Anthracospirifer</i>                           | 68; pl. 11                                    |
| form B, <i>Anthracospirifer</i>                           | 69; pl. 11                                    |
| <i>Spirifer</i>   | 67  |
| <i>oklahomae</i> , <i>Schizophoria</i>                    | 23  |
| <i>opimus</i> , <i>Anthracospirifer</i>                   | 68, 72  |
| <i>Spirifer</i>   | 3, 12, 71, 72                                 |
| <i>occidentalis</i> , <i>Spirifer</i>                     | 67  |
| <i>orbicularis</i> , <i>Cleiothyridina</i>                | 57, 58  |
| <i>Orbiculoidea</i>                                       | 3, 16, 21                                     |

|  | Page   |
|--|--|
| <i>wyomingensis</i> -----                                      | D2, 6, 12, 14, 15, 16, 21, 22; pl. 1                       |
| sp A -----   | 3, 6, 12, 15, 16, 21, 22; pl. 1                            |
| sp B -----   | 6, 13, 15, 16, 21; pl. 1                                   |
| Orthids -----  | 16   |
| Orthida -----  | 22   |
| Orthidina -----  | 22   |
| <i>Orthis carbonaria</i> -----                                 | 23   |
| <i>pecosi</i> -----  | 23   |
| <i>robusta</i> -----   | 31   |
| <i>Orthotetes</i> -----  | 5, 16, 29, 30, 31, 32                                      |
| <i>kaskaskiensis</i> -----                                     | 2, 29  |
| <i>bransonorum</i> -----                                       | 2, 3, 6, 11, 12, 15, 16, 29, 30, 31; pls. 1, 2             |
| <i>robusta</i> -----   | 32   |
| ( <i>Derbyia</i> ) sp -----                                    | 30   |
| ( <i>Orthotetes</i> ) sp -----                                 | 29, 30   |
| sp A -----   | 6, 13, 14, 15, 16, 30; pl. 2                               |
| sp -----   | 3, 6, 11, 15, 16, 29, 31; pl. 2                            |
| ( <i>Orthotetes</i> ), <i>Orthotetes</i> sp -----              | 29, 30   |
| Orthotetidae -----   | 5, 16, 29  |
| <i>Orthotetina</i> -----                                       | 5, 24, 28  |
| <i>amadenensis</i> -----                                       | 2, 6, 12, 15, 16, 19, 24, 27, 28; pl. 2                    |
| Orthotetoids -----   | 6, 11, 12, 13, 14, 16                                      |
| <i>osagensis</i> , <i>Wellerella</i> -----                     | 53, 54   |
| <i>ottumwa</i> , <i>Pugnoides</i> -----                        | 2, 53, 54  |
| <i>ovalis</i> , <i>Juresania</i> -----                         | 46   |
| <i>ovata</i> , <i>Composita</i> -----                          | 6, 13, 14, 15, 17, 20, 60, 63, 64; pl. 10                  |
| <i>Composita subtilita</i> -----                               | 3, 61, 62  |
| <i>Ovatia</i> -----  | 15, 16, 49   |
| <i>croneisi</i> -----  | 2, 3, 6, 12, 15, 49, 51, 52; pl. 6                         |
| <i>duodenaria</i> -----  | 50, 51   |
| <i>muralis</i> -----   | 3, 6, 11, 12, 15, 50, 52; pl. 6                            |
| <i>Overtoniidae</i> -----                                      | 5, 35  |
| <i>ozarkana</i> , <i>Composita</i> -----                       | 59   |
| P  |  |
| <i>pecosi</i> , <i>Orthis</i> -----                            | 23   |
| <i>Rhipidomella</i> -----                                      | 23   |
| <i>pellaensis</i> , <i>Anthracospirifer</i> -----              | 72   |
| <i>Spirifer</i> -----  | 2, 70, 71  |
| <i>pernodosa</i> , <i>Antiquatonia</i> -----                   | 47, 48, 49, 52   |
| <i>phillipsi</i> , <i>Carlina</i> -----                        | 43   |
| <i>Diaphragmus</i> -----                                       | 2, 42, 45  |
| <i>planiventralis</i> , <i>Linoproductus</i> -----             | 6, 13, 14, 15, 20, 52; pl. 5                               |
| <i>Pleurosiphonella drummondi</i> -----                        | 15   |
| <i>poposiensis</i> , <i>Composita</i> -----                    | 2, 3, 6, 12, 13, 15, 16, 17, 19, 60, 61, 63, 77; pls. 8, 9 |
| <i>Composita Subzone</i> -----                                 | 16, 17, 18, 19, 21, 54, 62, 72, 77, 78                     |
| <i>Schuchertella</i> -----                                     | 2, 6, 12, 13, 15, 16, 19, 28; pls. 1, 2                    |
| <i>Streptorhynchus</i> -----                                   | 2, 28  |
| <i>portlockianus</i> , <i>Dictyoclostus</i> -----              | 3, 36, 37  |
| <i>praenuntius</i> , <i>Neospirifer</i> -----                  | 6, 11, 15, 17, 75; pl. 13                                  |
| <i>prattenianus</i> , <i>Linoproductus</i> -----               | 3, 50, 51  |
| <i>Productacea</i> -----                                       | 35   |
| <i>Productidae</i> -----                                       | 5, 16, 39  |
| <i>Productidina</i> -----                                      | 35   |
| <i>Productoids</i> -----                                       | 6, 12, 16  |
| <i>Productus cestriensis</i> -----                             | 39   |
| <i>coloradoensis</i> -----                                     | 47   |
| <i>elegans</i> -----   | 39, 40   |
| <i>fasciculatus</i> -----                                      | 39, 40, 41   |
| <i>inflatus</i> -----  | 47   |
| <i>coloradoensis</i> -----                                     | 47   |
| <i>semistriatus</i> -----                                      | 38   |
| ( <i>Productus</i> ) <i>elegans</i> , <i>Diaphragmus</i> ----- | 39   |
| <i>pseudoliratus</i> , <i>Chonetes</i> -----                   | 33   |
| <i>Eolissochonetes</i> -----                                   | 4, 6, 12, 13, 14, 15, 16, 20, 33, 34, 35; pl. 1            |
| <i>Rugosochonetes</i> -----                                    | 52   |
| <i>Pugnoides</i> -----   | 5, 53  |
| <i>ottumwa</i> -----   | 2, 53, 54  |

|  | Page   |
|--|--|
| <i>quinqueplecis</i> -----                           | D2, 3, 4, 12, 13, 15, 16, 53, 79; pl. 7        |
| <i>Pulsia</i> -----                                  | 1, 5, 25                                       |
| <i>delira</i> -----                                  | 6, 14, 15, 16, 26, 27; pl. 2                   |
| <i>mosquensis</i> -----                              | 26   |
| sp A -----   | 6, 11, 13, 15, 16, 26, 27, 28; pl. 2           |
| sp -----   | 25   |
| ( <i>Pulsia</i> ), <i>Schellwienella</i> -----       | 25, 26   |
| <i>Pustula genevievensis</i> -----                   | 2, 42, 44, 45                                  |
| <i>globosa</i> -----                                 | 35   |
| Q  |  |
| <i>quinqueplecis</i> , <i>Pugnoides</i> -----        | 2, 3, 4, 6, 12, 13, 15, 16, 53, 79; pl. 7      |
| R  |  |
| <i>Ranchester Limestone Member</i> -----             | 13   |
| <i>ravilinsensis</i> , <i>Anthracospirifer</i> ----- | 6, 13, 15, 17, 69; pl. 11                      |
| <i>reupinoides</i> , <i>Schizophoria</i> -----       | 23   |
| <i>Retichonetes</i> -----                            | 33   |
| <i>Reticularia setigera</i> -----                    | 65   |
| <i>setigerus</i> -----                               | 65   |
| <i>Reticulariacea</i> -----                          | 65   |
| <i>Reticularina</i> -----                            | 75   |
| <i>browni</i> -----                                  | 2, 3, 6, 12, 13, 15, 18, 19, 75; pl. 13        |
| <i>gonionota</i> -----                               | 77   |
| <i>norwoodana</i> -----                              | 77   |
| <i>spinosa</i> -----                                 | 75, 77   |
| sp -----   | 6, 11  |
| <i>Retziacea</i> -----                               | 77   |
| <i>Retziidae</i> -----                               | 5, 77  |
| <i>Retziidina</i> -----                              | 77   |
| <i>Retziids and Terebratuloids</i> -----             | 18   |
| <i>Rhipidomella</i> -----                            | 5, 23  |
| <i>carbonaria</i> -----                              | 6, 13, 15, 16, 23; pl. 1                       |
| <i>gregeri</i> -----                                 | 2, 72, 73, 78                                  |
| <i>pecosi</i> -----                                  | 23   |
| <i>Rhipidomellidae</i> -----                         | 5, 23  |
| <i>rhomboidale</i> , <i>Coledium</i> -----           | 55   |
| <i>Rhynchonellacea</i> -----                         | 53   |
| <i>Rhynchonellida</i> -----                          | 53   |
| <i>Rhynchonelloids</i> -----                         | 16   |
| <i>robusta</i> , <i>Derbyia</i> -----                | 6, 13, 14, 15, 16, 27, 31; pl. 2               |
| <i>Orthis</i> -----                                  | 31   |
| <i>Orthotetes</i> -----                              | 32   |
| <i>rockymontanus</i> , <i>Anthracospirifer</i> ----- | 68   |
| <i>Rugoclostus</i> -----                             | 5, 16, 37, 38                                  |
| <i>nivalis</i> -----                                 | 37, 39, 43, 44                                 |
| <i>semistriatus</i> -----                            | 39   |
| <i>williamsi</i> -----                               | 6, 13, 15, 38; pl. 3                           |
| <i>Rugosochonetes</i> -----                          | 33   |
| <i>pseudoliratus</i> -----                           | 52   |
| S  |  |
| <i>saginata</i> , <i>Cleiothyridina</i> -----        |  |
| <i>atrypoides</i> -----                              | 6, 11, 12, 15, 17, 55; pl. 7                   |
| <i>salemensis</i> , <i>Spiriferina</i> -----         | 77   |
| <i>Schellwienella</i> -----                          | 26   |
| ( <i>Pulsia</i> ) -----                              | 25, 26   |
| <i>Schizophoria</i> -----                            | 5, 16, 22, 23                                  |
| <i>altirostris</i> -----                             | 23   |
| <i>depressa</i> -----                                | 2, 4, 6, 11, 12, 13, 14, 15, 16, 22, 23; pl. 1 |
| <i>oklahomac</i> -----                               | 23   |
| <i>resupinoides</i> -----                            | 23   |
| <i>schucherti</i> -----                              | 23   |
| <i>swallowi</i> -----                                | 2, 22  |
| <i>texana</i> -----                                  | 4, 6, 12, 14, 15, 16, 22; pl. 1                |
| <i>Schuchertella</i> -----                           | 5, 26, 28                                      |
| <i>poposiensis</i> -----                             | 2, 6, 12, 13, 15, 16, 19, 28; pls. 1, 2        |
| <i>Schuchertellidae</i> -----                        | 5, 28  |

|   | Page  |
|---|---|
| <i>schucherti</i> , <i>Schizophoria</i> -----                     | D23   |
| <i>Scoloconcha</i> -----  | 5, 16, 35                                       |
| <i>globosa</i> -----  | 6, 14, 15, 20, 35; pl. 3                        |
| <i>indianensis</i> -----  | 36  |
| <i>Selenella</i> -----  | 5, 78   |
| <i>walteri</i> -----  | 2, 6, 53, 54, 73                                |
| <i>Seminula subquadrata</i> -----                                 | 59  |
| <i>subtilita</i> -----  | 64  |
| <i>semistriatus</i> , <i>Productus</i> -----                      | 38  |
| <i>Rugoclostus</i> -----  | 39  |
| <i>sericius</i> , <i>Chonetes</i> -----                           | 33  |
| <i>setiger</i> , <i>Torynifer</i> -----                           | 6, 12, 18, 65; pl. 13                           |
| <i>setigera</i> , <i>Reticularia</i> -----                        | 65  |
| <i>Spirifera</i> -----  | 65  |
| <i>Torynifer</i> -----  | 65  |
| <i>setigerus</i> , <i>Reticularia</i> -----                       | 65  |
| <i>Spirifer</i> -----   | 65  |
| <i>shawi</i> , <i>Anthracospirifer</i> -----                      | 17, 19, 72, 73                                  |
| <i>Anthracospirifer shawi</i> -----                               | 2, 6, 12, 15, 17, 70, 71; pl. 12                |
| <i>welleri</i> Zone -----   | 16, 17, 19, 20                                  |
| <i>exoletus</i> , <i>Anthracospirifer</i> -----                   | 2, 3, 6, 12, 13, 14, 15, 17, 71, 72, 74; pl. 12 |
| <i>shawi</i> , <i>Anthracospirifer</i> -----                      | 2, 6, 12, 15, 17, 70, 71; pl. 12                |
| <i>shoshonensis</i> , <i>Anthracospirifer</i> -----               | 65, 70  |
| <i>Spirifer</i> -----   | 2, 65, 68, 75                                   |
| <i>sigma</i> , <i>Composita</i> -----                             | 2, 6, 12, 13, 14, 15, 17, 19, 59, 64; pls. 8, 9 |
| <i>spinolinearis</i> , <i>Inflatia</i> -----                      | 37  |
| <i>spinosa</i> , <i>Reticularina</i> -----                        | 75, 77  |
| <i>campestris</i> , <i>Spiriferina</i> -----                      | 3, 77   |
| <i>cochisensis</i> , <i>Spiriferina</i> -----                     | 77  |
| <i>spinosus</i> , <i>Spirifer</i> -----                           | 77  |
| <i>Spirifer adonis</i> -----                                      | 70  |
| <i>boonensis</i> -----  | 67  |
| <i>curvilateralis</i> -----                                       | 65  |
| <i>increbescens</i> -----   | 65, 66  |
| <i>norwoodanus</i> -----  | 77  |
| <i>occidentalis</i> -----   | 67  |
| <i>occiduus</i> -----   | D67   |
| <i>opimus</i> -----   | 3, 12, 71, 72                                   |
| <i>occidentalis</i> -----   | 67  |
| <i>pellaensis</i> -----   | 2, 70, 71                                       |
| <i>setigerus</i> -----  | 65  |
| <i>shoshonensis</i> -----   | 2, 65, 68, 75                                   |
| <i>spinosus</i> -----   | 77  |
| <i>welleri</i> -----  | 2, 3, 12, 72, 73                                |
| sp -----  | 3, 71   |
| <i>Spirifera setigera</i> -----                                   | 65  |
| <i>Spiriferacea</i> -----   | 65  |
| <i>Spiriferellina lata</i> -----                                  | 77  |
| <i>Spiriferida</i> -----  | 55  |
| <i>Spiriferidae</i> -----   | 5, 17, 65                                       |
| <i>Spiriferidina</i> -----  | 65  |
| <i>Spiriferids</i> -----  | 17  |
| <i>Spiriferina</i> -----  | 77  |
| <i>browni</i> -----   | 2, 75, 77                                       |
| <i>gonionota</i> -----  | 3, 77   |
| <i>salemensis</i> -----   | 77  |
| <i>spinosa campestris</i> -----                                   | 3, 77   |
| <i>cochisensis</i> -----  | 77  |
| <i>subspinosa</i> -----   | 77  |
| <i>Spiriferinacea</i> -----                                       | 75  |
| <i>Spiriferinidae</i> -----                                       | 5, 18   |
| <i>stelcki</i> , <i>Lonsdaleia</i> ( <i>Actinocyathus</i> ) ----- | 15  |
| <i>Stenosclimatacea</i> -----                                     | 54  |
| <i>Stenosclimatidae</i> -----                                     | 5, 54   |
| Stratigraphic and geologic distribution                           |   |
| of the brachiopods -----  | 5   |
| <i>Streptorhynchus</i> -----                                      | 28  |
| <i>poposiensis</i> -----  | 2, 28   |
| <i>striaticostata</i> , <i>Meekella</i> -----                     | 25  |
| <i>Strophomenida</i> -----  | 24  |
| <i>Strophomenidina</i> -----                                      | 24  |
| <i>subcuneata</i> , <i>Tetracamera</i> -----                      | 2   |
| <i>sublamellosa</i> , <i>Caninia</i> -----                        | 17  |
| <i>Cleiothyridina</i> -----                                       | 6, 11, 56, 57, 58; pl. 7                        |
| <i>subquadrata</i> , <i>Athyris</i> -----                         | 59  |

|                                      | Page   |
|--------------------------------------|--|
| <i>Composita</i> -----               | D6, 11, 12, 15, 17, 19, 58,<br>59, 63; pls. 8, 9 |
| <i>Seminula</i> -----                | 59   |
| <i>subspinoso, Spiriferina</i> ----- | 77   |
| <i>subtilita, Composita</i> -----    | 6, 14, 15, 17, 62,<br>64; pl. 10                 |
| <i>Composita subtilita</i> -----     | 3, 61, 62  |
| <i>ovata, Composita</i> -----        | 3, 61, 62  |
| <i>subtilita, Composita</i> -----    | 3, 61, 62  |
| <i>trinuclea, Composita</i> -----    | 3, 61  |
| <i>Seminula</i> -----                | 64   |
| <i>Terebratula</i> -----             | 64   |
| <i>sulcata, Composita</i> -----      | 3, 6, 12, 15, 17, 19, 59,<br>62; pl. 8           |
| <i>Eumetria</i> -----                | 2, 3, 6, 12, 13, 14, 15, 18,<br>77; pl. 13       |
| <i>suttoni, Chonetes</i> -----       | 34, 35   |
| <i>Eolisochonetes</i> -----          | 6, 16, 34; pl. 1                                 |
| <i>swalovi, Schizophoria</i> -----   | 2, 22  |
| <i>symmetrica, Juresania</i> -----   | 46   |

| T                                   | Page                               |
|-------------------------------------|------------------------------------|
| <i>Terebratula subtilita</i> -----  | D64                                |
| <i>Terebratulida</i> -----          | 78                                 |
| <i>Terebratulidina</i> -----        | 78                                 |
| <i>Tetracamera subcuneata</i> ----- | 2                                  |
| <i>texana, Schizophoria</i> -----   | 4, 6, 12, 14, 15,<br>16, 22; pl. 1 |
| <i>Torynifer</i> -----              | 5, 57, 65                          |
| <i>setiger</i> -----                | 6, 12, 18, 65; pl. 13              |
| <i>setigera</i> -----               | 65                                 |
| <i>trinuclea, Composita</i> -----   | 2, 59, 61, 62                      |
| <i>Composita subtilita</i> -----    | 3, 61                              |

| V                                    |           |
|--------------------------------------|-----------|
| <i>verneuilliana, Eumetria</i> ----- | 2, 77, 78 |
| <i>vittatus, Echinoconchus</i> ----- | 44        |

| W  |                                  |
|--|----------------------------------|
| <i>walteri, Selenella</i> -----            | 2, 6, 53, 54, 78                 |
| <i>washakiensis, Brachythyridina</i> ----- | 6, 11, 12, 15,<br>17, 74; pl. 13 |

|   | Page   |
|---|--|
| <i>Wellerella osagensis</i> -----                     | D53, 54  |
| sp. A -----   | 54   |
| sp. B -----   | 54   |
| sp -----  | 54   |
| <i>welleri, Anthracospirifer</i> -----                | 17, 19, 73, 74                                 |
| <i>Anthracospirifer welleri</i> -----                 | 2, 3, 6, 12,<br>15, 17, 60, 71, 72, 74; pl. 12 |
| <i>lincolnensis,</i><br><i>Anthracospirifer</i> ----- | 6, 12, 13, 15,<br>17, 73; pl. 13               |
| <i>welleri, Anthracospirifer</i> -----                | 2, 3, 6, 12, 15,<br>17, 60, 71, 72, 74; pl. 12 |
| <i>Spirifer</i> -----                                 | 2, 3, 12, 72, 73                               |
| <i>welleri-shawi, Anthracospirifer</i><br>Zone -----  | 16, 17, 19, 20                                 |
| <i>williamsi, Rugoclostus</i> -----                   | 6, 13, 15, 38; pl. 3                           |
| <i>wyomingensis, Chaetetes</i> -----                  | 15   |
| <i>Orbiculoidea</i> -----                             | 2, 6, 12, 14, 15, 16,<br>21, 22; pl. 1         |
| Z   |  |
| Zonal distribution of the brachiopods --              | 14   |

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## PLATES 1-13

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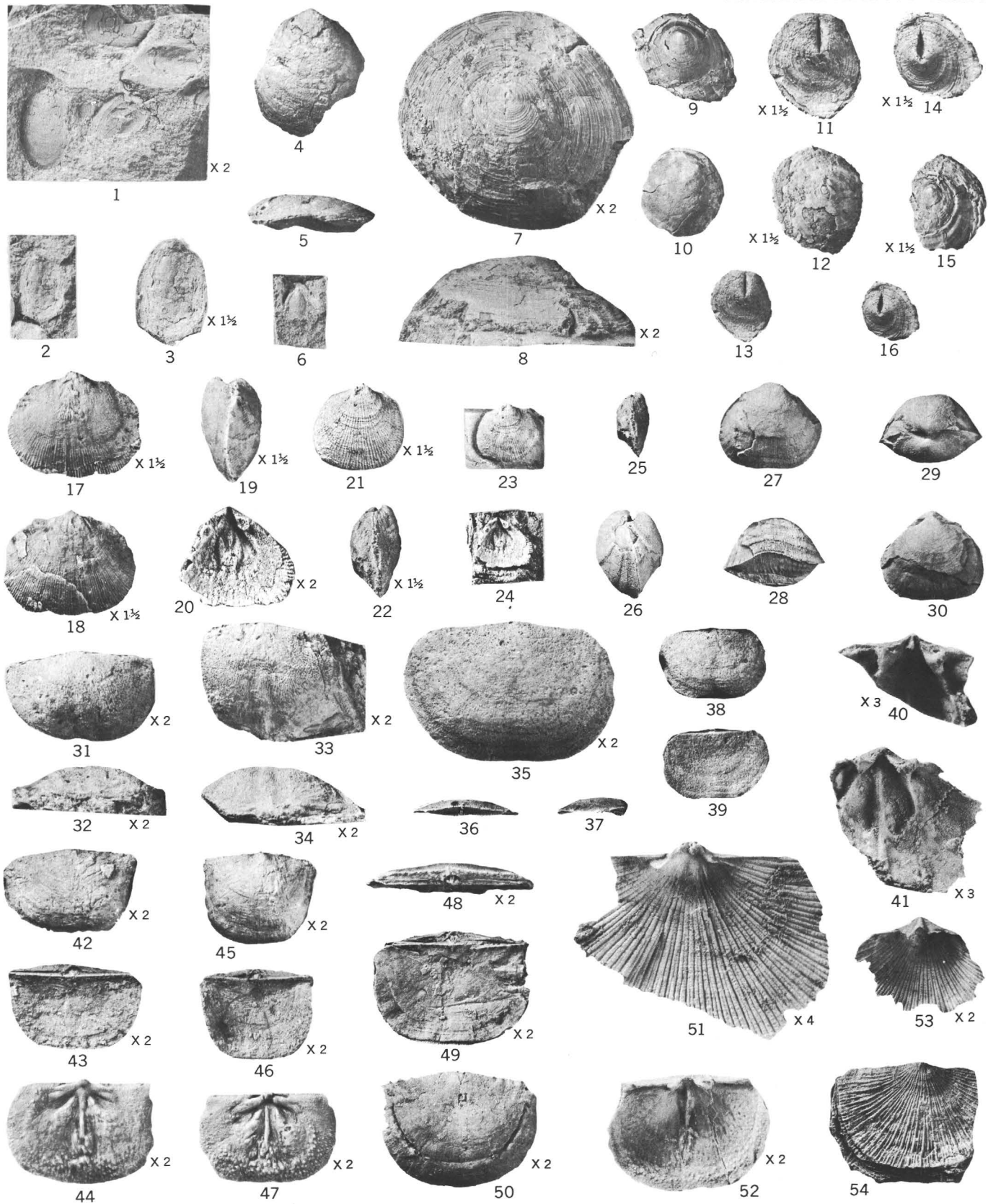
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# PLATE 1

[Figures natural size unless otherwise indicated on plate]

## FIGURES

- 1-3, 6. *Lingula* cf. *L. carbonaria* Shumard (p. D20).
  1. Enlarged view of specimens, USNM 163703A, from Horseshoe Shale Member, collection 46.
  - 2, 3. Exterior view and enlarged view of specimen, USNM 163704, from Ranchester Limestone Member, collection 139.
  6. Exterior view of another specimen, USNM 163703B, collection 46.
- 4, 5, 10. *Orbiculoidea* sp. A (p. D21).
  - 4, 5. Exterior and side views of pedicle valve with nearly marginal apex, UW IT-185, from Horseshoe Shale Member, collection 21.
  10. Pedicle valve with apex slightly farther from margin, UW IT-184, collection 21.
- 7, 8. *Orbiculoidea* sp. B. (p. D21).
  - Enlarged pedicle and side views of specimen, USNM 163706, from Ranchester Limestone Member, collection 3.
- 9, 11-16. *Orbiculoidea wyomingensis* Branson and Greger (p. D21).
  - From Horseshoe Shale Member.
  9. Pedicle valve of paralectotype, UM 2641, collection 36a.
  - 11-13. Enlarged brachial and pedicle views and brachial view of nearly complete specimen, USNM 163705, collection 38.
  - 14-16. Enlarged brachial and pedicle views and brachial view of lectotype, UM 2641, collection 36a.
- 17-19. *Schizophoria depressa* Easton (p. D22).
  - Enlarged pedicle, brachial, and side views of specimen, USNM 163707, from Horseshoe Shale Member, collection 45.
- 20-25. *Rhipidomella carbonaria* (Swallow) (p. D23).
  - From Ranchester Limestone Member, collection 86.
  - 20, 24. Views of pedicle valve interior, USNM 163718.
  - 21, 23. Views of pedicle valve exterior, USNM 163717.
  - 22, 25. Side views of specimen, USNM 163716.
- 26-30, 40, 41. *Schizophoria* aff. *S. texana* Girty (p. D22).
  - From Ranchester Limestone Member.
  - 26-30. Side, brachial, anterior, posterior, and pedicle views of well-preserved specimen, USNM 163713, collection 68.
  - 40, 41. Enlarged views of apical region of brachial valve, USNM 167315, and of pedicle valve, USNM 167314, collection 67.
- 31-34. *Mesolobus* sp. (p. D35).
  - 31, 32. Enlarged exterior and anterior views of pedicle valve, USNM 163746, from Ranchester Limestone Member, collection 15.
  - 33, 34. Enlarged exterior and anterior views of another pedicle valve, USNM 163747, collection 15.
- 35-39. *Eolissochonetes? suttoni* (C. Branson) (p. D34).
  - Enlarged pedicle view and posterior, side, pedicle, and brachial views of holotype and only known example, UM 6832, from Horseshoe Shale Member, collection 36d.
- 42-50, 52. *Eolissochonetes pseudoliratus* (Easton) (p. D33).
  - From Horseshoe Shale Member, collection 157.
  - 42, 43. Enlarged pedicle and brachial views of fairly complete specimen, USNM 163742.
  44. Enlarged view of interior of brachial valve, USNM 163744.
  - 45, 46. Enlarged pedicle and brachial views of a narrower specimen, USNM 163741.
  47. Enlarged view of brachial valve interior, USNM 163475.
  48. Enlarged view of interarea of another specimen, USNM 163740.
  - 49, 50. Enlarged brachial and pedicle views of another shell, USNM 163739.
  52. Enlarged view of interior of pedicle valve USNM 163743.
- 51, 53. *Schuchertella* cf. *S. poposiensis* (C. Branson) (p. D28).
  51. Enlarged interior view of brachial valve showing details of cardinal process, USNM 163727, from Horseshoe Shale Member, collection 69.
  53. Enlarged view showing interior of pedicle valve, USNM 163709, collection 69.
54. *Orthotetes kaskaskiensis bransonorum* n. subsp. (p. D29).
  - Exterior of incomplete but well-preserved pedicle valve, USNM 163729, from Horseshoe Shale Member, collection 27.



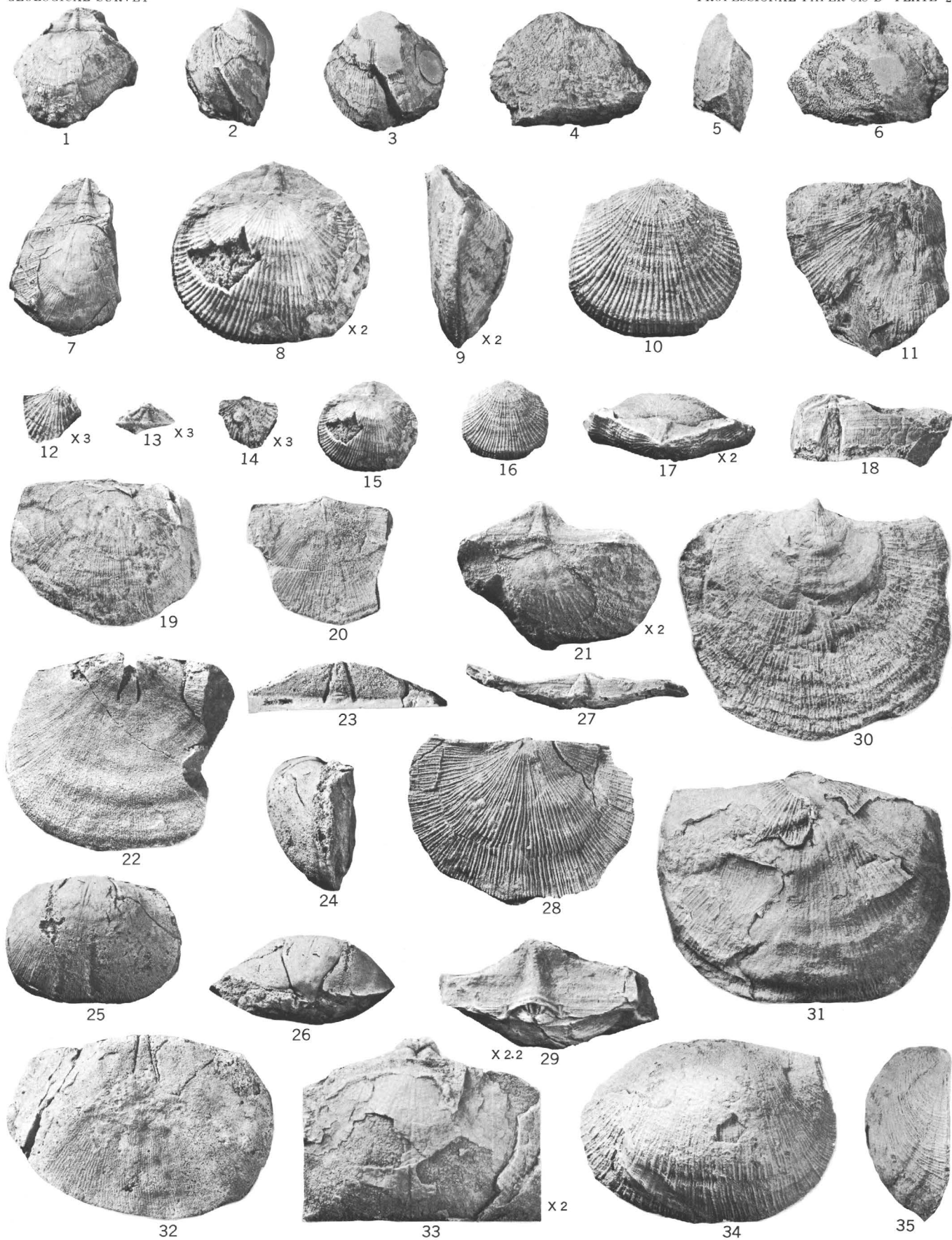
LINGULA, ORBICULOIDEA, SCHIZOPHORIA, RHIPIDOMELLA, MESOLOBUS,  
EOLISSOCHONETES, SCHUCHERTELLA, AND ORTHOTETES



## PLATE 2

[Figures natural size unless otherwise indicated on plate]

- FIGURES 1-3, 7. *Orthotetina amsdenensis* (Branson and Greger) (p. D24).  
 1-3. Brachial, side, and pedicle views of lectotype, UM 2643, from Horseshoe Shale Member, collection 36b. Umbonal region of pedicle valve ground down slightly.  
 7. Brachial view of paralectotype, UM 2643, collection 36b.
- 4-6. *Pulsia* sp. A (p. D27).  
 Pedicle, side, and brachial views of eroded specimen, USNM 163719, from Moffat Trail Limestone Member, collection 72.
- 8-10, 12-17. *Schuchertella poposiensis* (C. Branson) (p. D28).  
 From Horseshoe Shale Member.  
 8, 9, 15. Enlarged brachial and side views of brachial view of hypotype, USNM 163740, collection E.  
 10, 16, 17. Enlarged brachial view, brachial view, and enlarged posterior view of another hypotype, USNM 163739, collection E.  
 12-14. Enlarged pedicle, posterior, and brachial views of C. Branson's largest paratype, UM 6833, collection 36d.
- 11, 18. *Orthotetes* sp. (p. D31).  
 A unique specimen, USNM 163730, from Moffat Trail Limestone Member, collection 93.
- 19-21. *Orthotetes* sp. A (p. D30).  
 From Horseshoe Shale Member.  
 19. View of brachial valve, USNM 163732, collection 54.  
 20. View of pedicle valve, USNM 163731, collection 54.  
 21. Enlarged oblique view showing interarea of fairly complete specimen, USNM 163733, collection 53.
- 22-26, 32. *Pulsia delira* n. sp. (p. D26).  
 From Ranchester Limestone Member, collection 52.  
 22. Pedicle valve preserved in fine sandstone, a paratype, USNM 163722.  
 23, 32. Posterior and ventral views of another pedicle valve, the holotype, USNM 163721.  
 24-26. Side, dorsal, and posterior views of brachial valve, a paratype, USNM 163724.
- 27-29. *Orthotetes kaskaskiensis bransonorum* n. subsp. (p. D29).  
 From Horseshoe Shale Member.  
 27, 28. Posterior (showing interarea) and brachial views of holotype, UM 2642a, collection 36a.  
 29. Enlarged view of interarea of pedicle valve and apical part of brachial valve, USNM 163728, collection 27.
- 30, 31, 33-35. *Derbyia* cf. *D. robusta* (Hall) (p. D31).  
 From Horseshoe Shale Member.  
 30. View of pedicle valve, USNM 163737, collection 2.  
 31. View of pedicle valve, USNM 163734, collection 3.  
 33. Partly oblique enlarged view of posterior part of brachial valve showing cardinal process, USNM 163736, collection 3.  
 34, 35. Dorsal and side views of brachial valve, USNM 163735, collection 3.



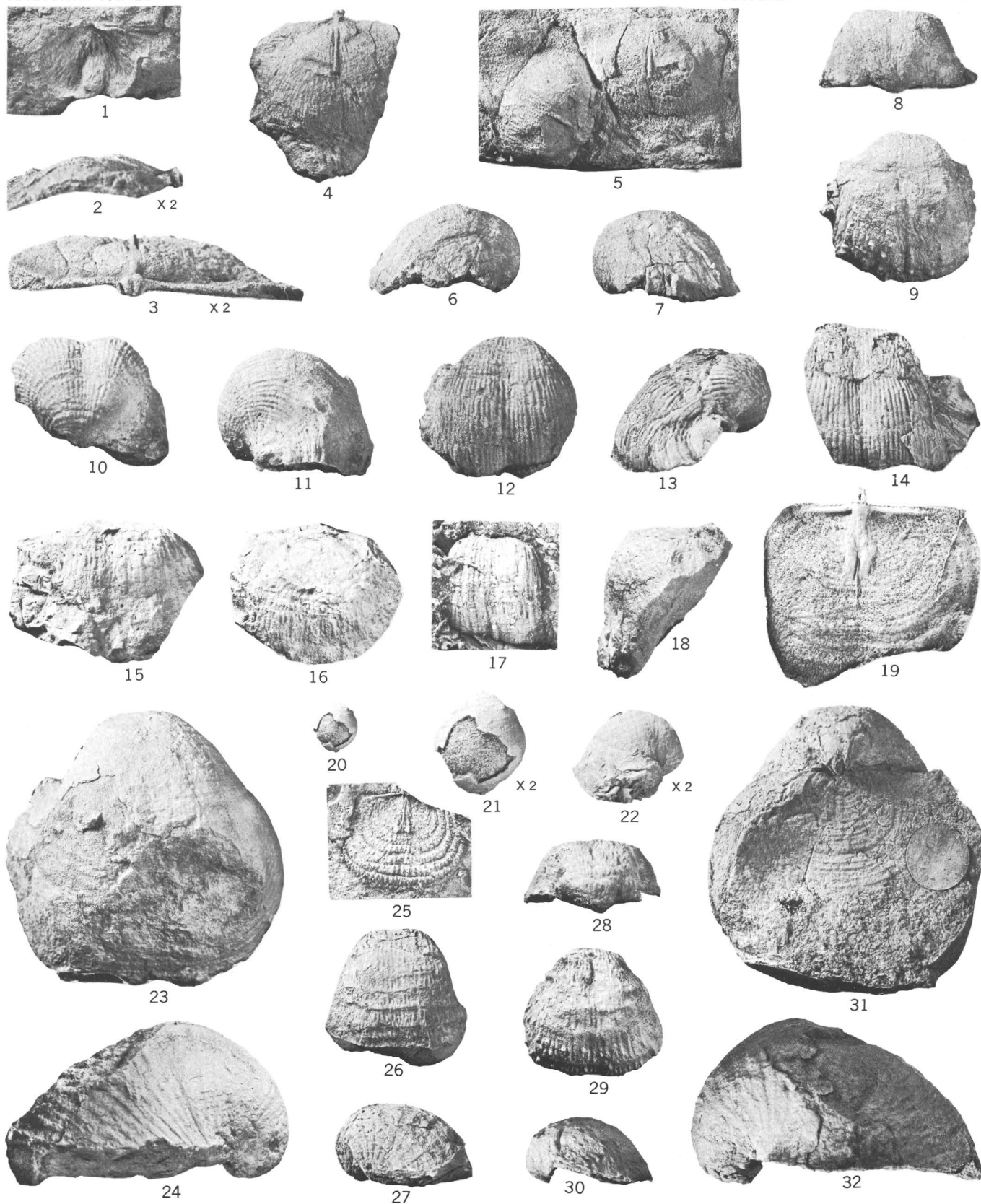
*ORTHOTETINA, PULSIA, SCHUCHERTELLA, ORTHOTETES, AND DERBYIA*

# PLATE 3

[Figures natural size unless otherwise indicated on plate]

## FIGURES

- 1-9. *Inflatia lovei* n. sp. (p. D36).  
From Horseshoe Shale Member, collection 47.
  1. Interior of pedicle valve, paratype, USNM 163750, showing adductor muscle-scar platform.
  - 2-4. Enlarged side and posterior views and dorsal view of brachial valve, paratype, USNM 163751.
  5. Two brachial valve interiors on slab, paratypes, USNM 163752a, b.
  - 6-9. Both sides, posterior, and ventral views of pedicle valve, holotype, USNM 163749.
- 10-16, 18. *Rugoclostus williamsi* n. sp. (p. D38).  
From Ranchester Limestone Member.
  - 10-12. Posterior, side, and ventral views of pedicle valve, holotype, USNM 163754, collection 100.
  - 13, 14. Side and ventral views of pedicle valve, paratype, USNM 163755, collection 100.
  - 15, 16, 18. Anterior, ventral, and side views of external mold of brachial valve, paratype USNM 163757, collection 100. In figure 15, tiny black dots mark bases of external spines.
17. *Rugoclostus* cf. *R. williamsi* n. sp. (p. D39).  
Latex cast of small pedicle valve, USNM 167719, from Ranchester Limestone Member, collection 83.
- 19, 23, 24, 31, 32. *Echinoconchus* sp. A (p. D43).  
From Horseshoe Shale Member.
  19. Latex cast showing interior of brachial valve, USNM 163789, collection 1.
  - 23, 24, 31, 32. Pedicle, side, brachial, and opposite side views of nearly complete specimen, USNM 163788, collection 5.
- 20-22. *Scolonconcha globosa* (Mather) (p. D35).  
Ventral view and enlarged ventral and side views of pedicle valve, USNM 163790, from Ranchester Limestone Member, collection 13.
- 25-27. *Juresania* sp. (p. D45).
  25. Latex cast of brachial valve interior, USNM 163771, from Ranchester Limestone Member, collection 142.
  - 26, 27. Ventral and side views of pedicle valve, USNM 163772, from Horseshoe Shale Member, collection 54.
- 28-30. *Flexaria* sp. (p. D44).  
Posterior, ventral, and side views of pedicle valve, UM 2646, from Horseshoe Shale Member, collection 36a.



*INFLATIA, RUGOCLOSTUS, ECHINOCONCHUS, SCOLOCONCHA, JURESANIA, AND FLEXARIA*

## PLATE 4

[Figures natural size unless otherwise indicated on plate]

FIGURES 1-4, 15-20, 22. *Diaphragmus cestriensis* (Worthen) (p. D39).

From Moffat Trail Limestone Member.

1-4. Posterior, ventral, anterior, and side views of pedicle valve, USNM 163764, collection 121.

15-18. Enlarged side view and posterior, ventral, and side views of pedicle valve, USNM 163766, collection 122.

19. Enlarged view of latex cast showing brachial valve interior, USNM 163765, collection 121.

20, 22. Top views of partly decorticated visceral disc of brachial valve showing diaphragm, USNM 163710, collection 122.

5-14. *Diaphragmus nivosus* n. sp. (p. D40).

5, 6, 12-14. Posterior, anterior, side, and ventral views and view of diaphragm area of holotype, USNM 163758, from Heath Formation, USGS collection 13425-PC, Big Snowy Mountains, Mont.

7. Latex cast of exterior of brachial valve, USNM 163759, paratype from type locality.

8-10. Posterior, ventral, and side views of fairly complete pedicle valve, USNM 163768, from Horseshoe Shale Member, collection 41.

11. View of brachial valve, showing diaphragm, USNM 163769, collection 41.

21, 23-37. *Carlinia amsdeniana* Gordon (p. D42).

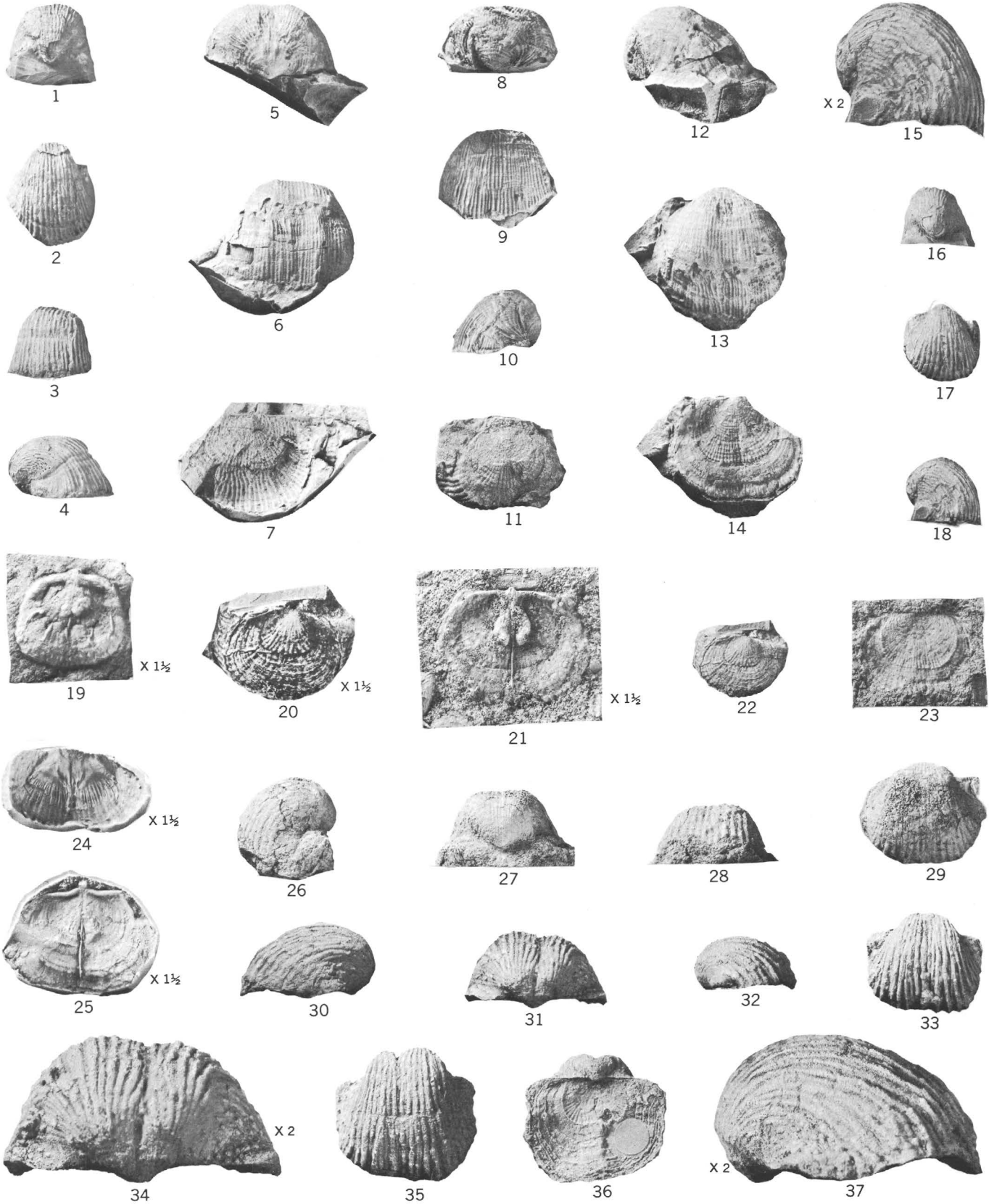
From Horseshoe Shale Member.

21, 23. Enlarged view of brachial valve interior preserved in fine sandstone and view of exterior of same valve, UW A11094, collection 31.

24, 25. Enlarged views of latex casts of pedicle valve interior and brachial valve interior from same internal mold, USNM 163762, paratype, collection 27.

26-29. Side, posterior, anterior, and ventral views of pedicle valve, UW A11119, collection 28.

30, 31, 34-37. Side, posterior, enlarged posterior, pedicle, brachial, and enlarged side views of holotype, UM 2645, collection 36a.



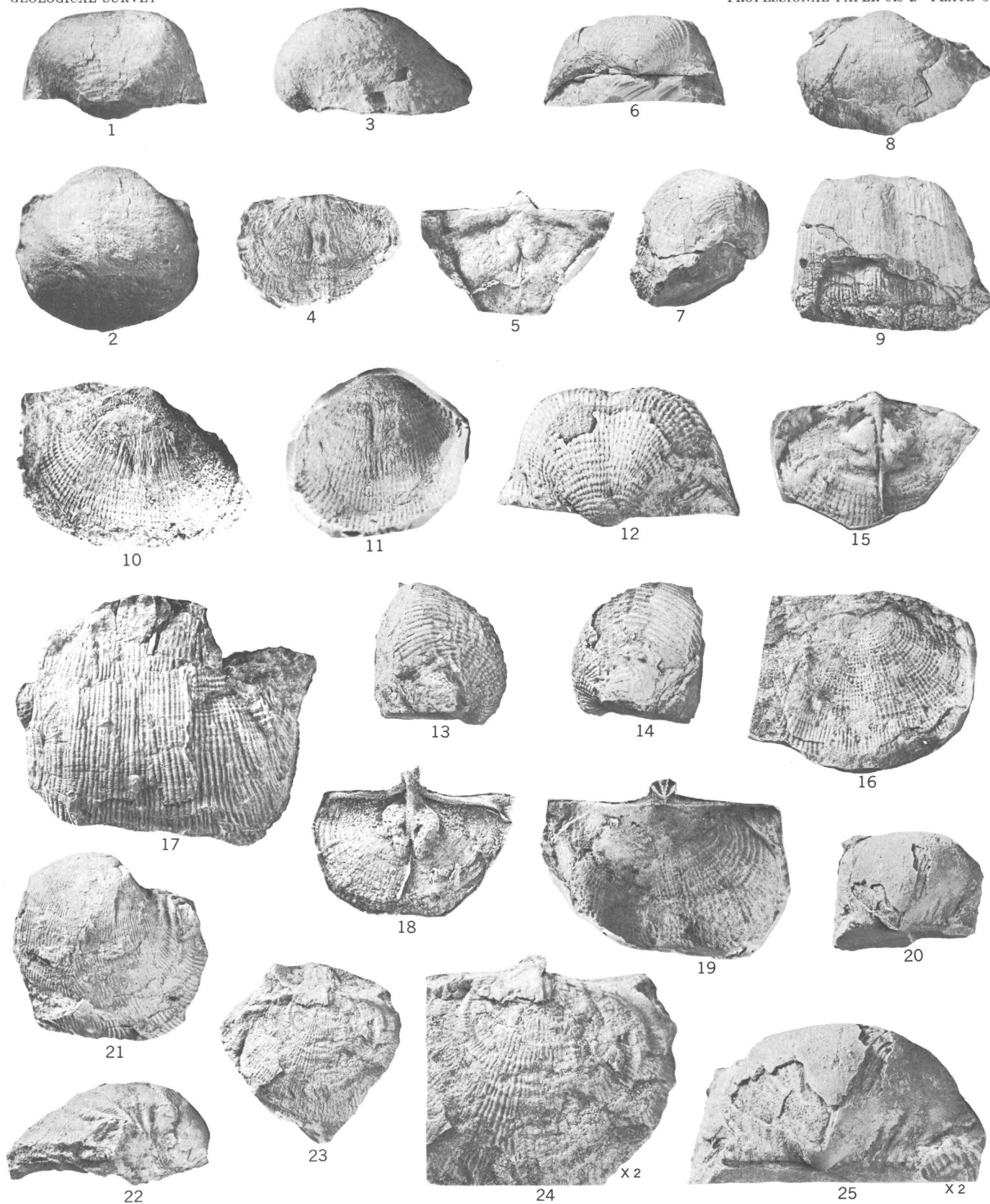
DIAPHRAGMUS AND CARLINIA

## PLATE 5

[Figures natural size unless otherwise indicated on plate]

- FIGURES 1-9. *Antiquatonia* cf. *A. coloradoensis* (Girty) (p. D47).  
1-3. Posterior, ventral, and side views of a worn pedicle valve, USNM 163783, from Ranchester Limestone Member, collection 6.  
4. Latex cast showing interior of pedicle valve with adductor muscle-scar platform, USNM 163785, from Horseshoe Shale Member, collection 53.  
5. Latex cast crudely showing part of brachial valve interior, USNM 163784, from Ranchester Limestone Member, collection 6.  
6-9. Posterior, side, pedicle, and anterior views of shell having pathologic median fold on anterior slope, USNM 163782, from Ranchester Limestone Member, collection 13.
- 10-19. *Antiquatonia blackwelderi* n. sp. (p. D46).  
From Ranchester Limestone Member.  
10. Latex cast showing interior of pedicle valve and its musculature, paratype, USNM 163777, collection 83.  
11. Latex cast showing interior of pedicle valve of another paratype, USNM 163780, collection 131.  
12-14. Posterior and both sides of holotype, USNM 163774, collection 133.  
15. Latex cast showing part of brachial valve interior, paratype, USNM 163779, collection 131.  
16. Latex cast showing exterior of brachial valve, paratype, USNM 163775, collection 133.  
17. Large crushed pedicle valve, paratype, USNM 163776, collection 139.  
18, 19. Latex casts showing interior and exterior of the same brachial valve, paratype, USNM 163778, collection 130.
- 20-25. *Linoproductus planiventralis* Hoare (p. D52).  
From Horseshoe Shale Member, collection 3.  
20, 25. Posterior view and enlarged posterior view of pedicle valve, USNM 167716.  
21, 22. Ventral and side views of pedicle valve, USNM 167715.  
23, 24. Interior views of partly decorticated brachial valve showing cardinal process, USNM 167718.



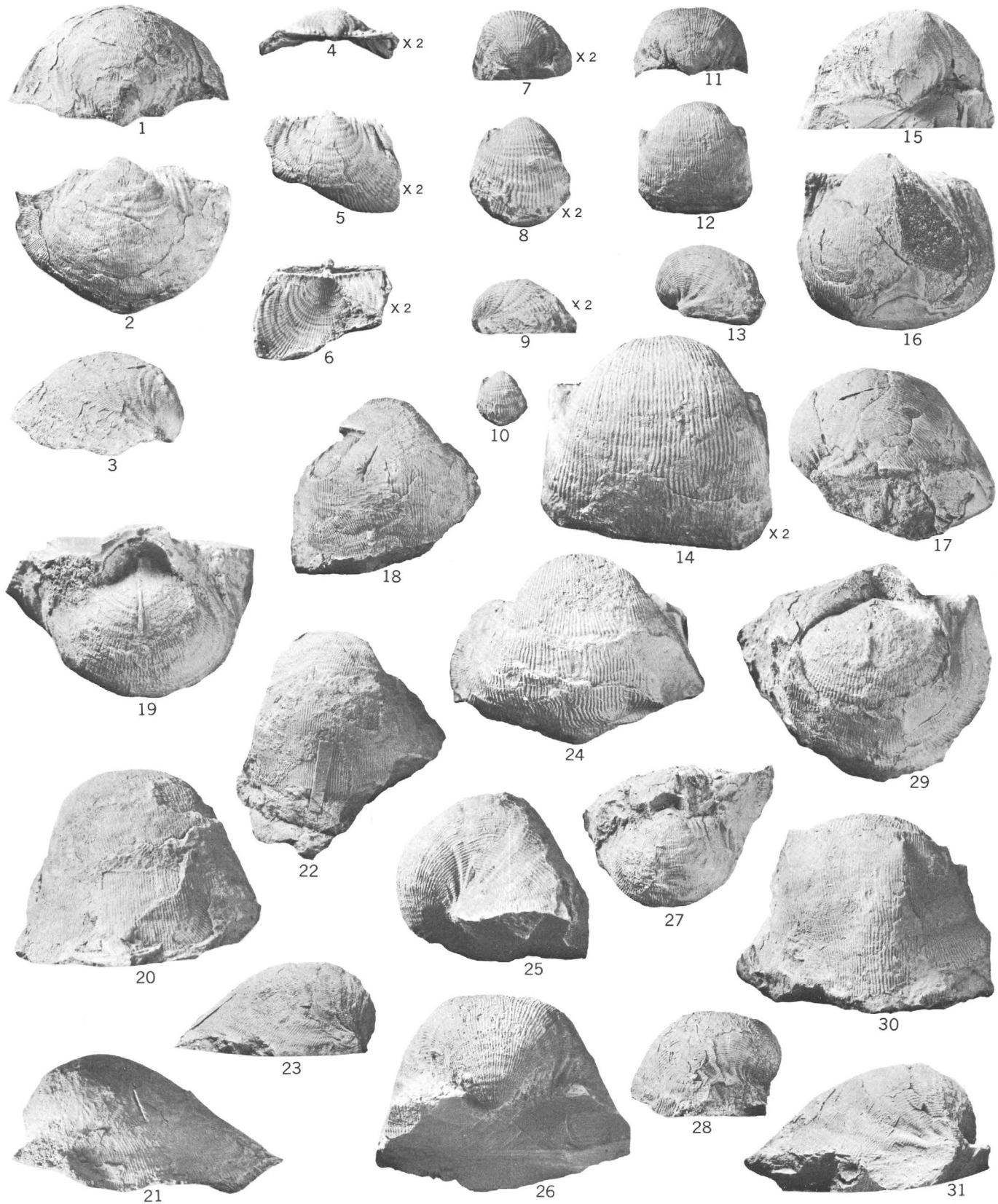


*ANTIQUATONIA AND LINOPRODUCTUS*

## PLATE 6

[Figures natural size unless otherwise indicated on plate]

- FIGURES 1-6. *Ovatia croneisi* (C. Branson) (p. D49).  
From Horseshoe Shale Member.  
1-3. Posterior, ventral, and side views of a nearly complete pedicle valve, UW A1281, hypotype collection 31.  
4-6. Enlarged posterior, pedicle and brachial views of holotype, UM 6831, an immature specimen, collection 36d.
- 7-17. *Ovatia muralis* n. sp. (p. D50).  
7-10. Enlarged posterior, pedicle, and side views and pedicle view of immature pedicle valve, USNM 163792, from Moffat Trail Limestone Member, collection 93.  
11-14. Posterior, pedicle, and side views and enlarged pedicle view of specimen USNM 163795, from Horseshoe Shale Member, collection 45.  
15-17. Posterior, pedicle, and side views of holotype, USNM 163791, pedicle valve, having anteroventral part restored, from Moffat Trail Limestone Member, collection 93.
- 18-31. *Linoproductus eastoni* n. sp. (p. D51).  
18, 28. Pedicle and side views of paratype, USNM 163801, from Horseshoe Shale Member, collection 53.  
19-21. Interior, anterior, and side views of well-preserved brachial valve with parts of pedicle valve adhering, holotype, USNM 163796, from uppermost Cameron Creek Member of the Tyler Formation or lowermost Alaska Bench Limestone, USGS collection 16177-PC, Big Snowy Mountains, Mont.  
22, 23, 27. Anterior, side, and interior, partly decorticated, views of similar brachial valve, USNM 163800, from Horseshoe Shale Member, collection 54.  
24-26. Pedicle, side, and posterior views of pedicle valve, paratype, USNM 163797, from type locality.  
29-31. Pedicle, anterior, and side views of incomplete specimen exposing visceral disk of brachial valve and possessing weak median fold in pedicle valve, paratype, USNM 163798, from type locality.



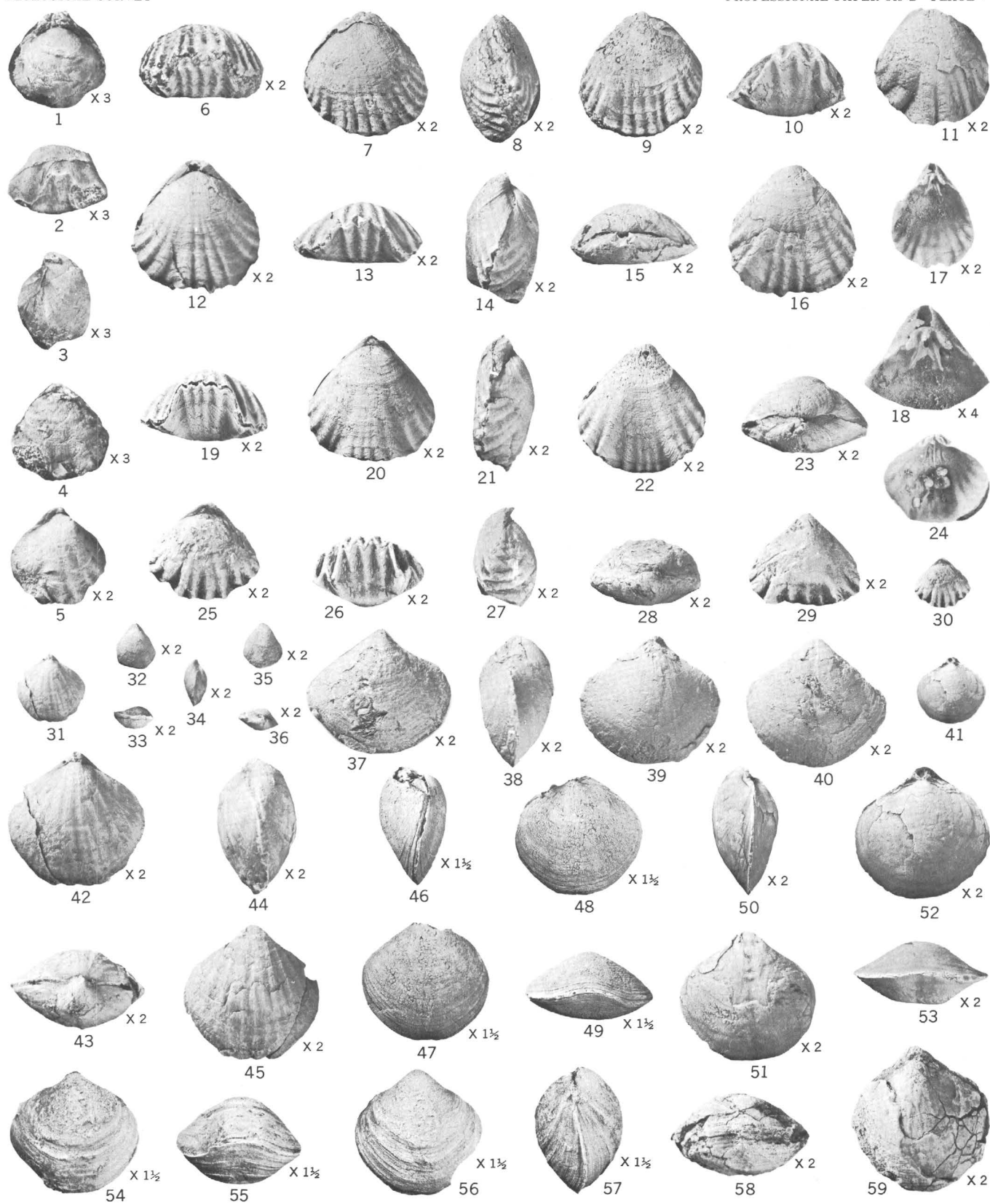
*OVATIA AND LINOPRODUCTUS*

## PLATE 7

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### FIGURES

- 1-5, 32-36. *Coledium fragum* n. sp. (p. D54).  
 From Moffat Trail Limestone Member, collection 93.  
 1-4. Enlarged brachial, anterior, side, and pedicle views of holotype, USNM 167730.  
 5. Enlarged brachial view of paratype, USNM 167731.  
 32-36. Enlarged brachial, anterior, side, pedicle, and posterior views of an immature paratype, USNM 167732.
- 6-30. *Pugnoides quinqueplecis* (Easton) (p. D53).  
 From Horseshoe Shale Member, unless otherwise noted.  
 6-9. Enlarged anterior, brachial, side, and pedicle views of specimen having five costae on fold, USNM 167725, collection 38.  
 10, 11. Enlarged anterior and brachial views of another specimen, having three costae on fold, USNM 167726, collection 38.  
 12-16. Enlarged brachial, anterior, side, posterior, and pedicle views of specimen having four costae on fold, USNM 167721, collection B.  
 17, 18. Enlarged views of interior of pedicle valve articulated with perforated hinge plate of brachial valve, USNM 167723, collection 69.  
 19-23. Enlarged anterior, brachial, side, pedicle, and posterior views of another specimen having five costae on fold, USNM 167722, collection D.  
 24. Enlarged view of interior of brachial valve to which adhere several silicified pellets, USNM 167724, from collection 69.  
 25-30. Enlarged brachial, anterior, side, posterior, and pedicle views and brachial view of sort subtriangular variant, USNM 167720 from Ranchester Limestone Member, collection 82.
- 31, 38-40, 42-45, 58, 59. *Cleiothyridina hirsuta darwinensis* n. subsp. (p. D56).  
 From Horseshoe Shale Member.  
 31, 42-45. Brachial view and enlarged brachial, posterior, side, and pedicle views of holotype, USNM 168391, from collection 137.  
 38-40. Enlarged pedicle, side, and brachial views of paratype, UM 6623, from collection 36e.  
 58, 59. Enlarged anterior and brachial views of weathered specimen, USNM 168393, from collection 27.
37. *Cleiothyridina* aff. *C. sublamellosa* (Hall) (p. D58).  
 Enlarged ventral view of pedicle valve, USNM 168453, from Moffat Trail Limestone Member, collection 93.
- 41, 50-53. *Cleiothyridina* aff. *C. elegans* Girty (p. D57).  
 Brachial view and enlarged side, pedicle brachial and anterior views of specimen figured by Branson and Greger (1918, pl. 19, fig. 14) as *C. hirsuta* (Hall), UM 2654, from Horseshoe Shale Member, collection 36a.
- 46-49. *Cleiothyridina hirsuta darwinensis* n. subsp.? (p. D56).  
 Enlarged side, pedicle, brachial, and anterior views of specimen replaced by chert, USNM 168452, from Horseshoe Shale Member, collection A.
- 54-57. *Cleiothyridina atrypoides saginata* n. subsp. (p. D55).  
 Enlarged brachial, anterior, pedicle, and side views of holotype, USNM 168390, from Horseshoe Shale Member, collection 41.



COLEDIUM, PUGNOIDES, AND CLEIOTHYRIDINA

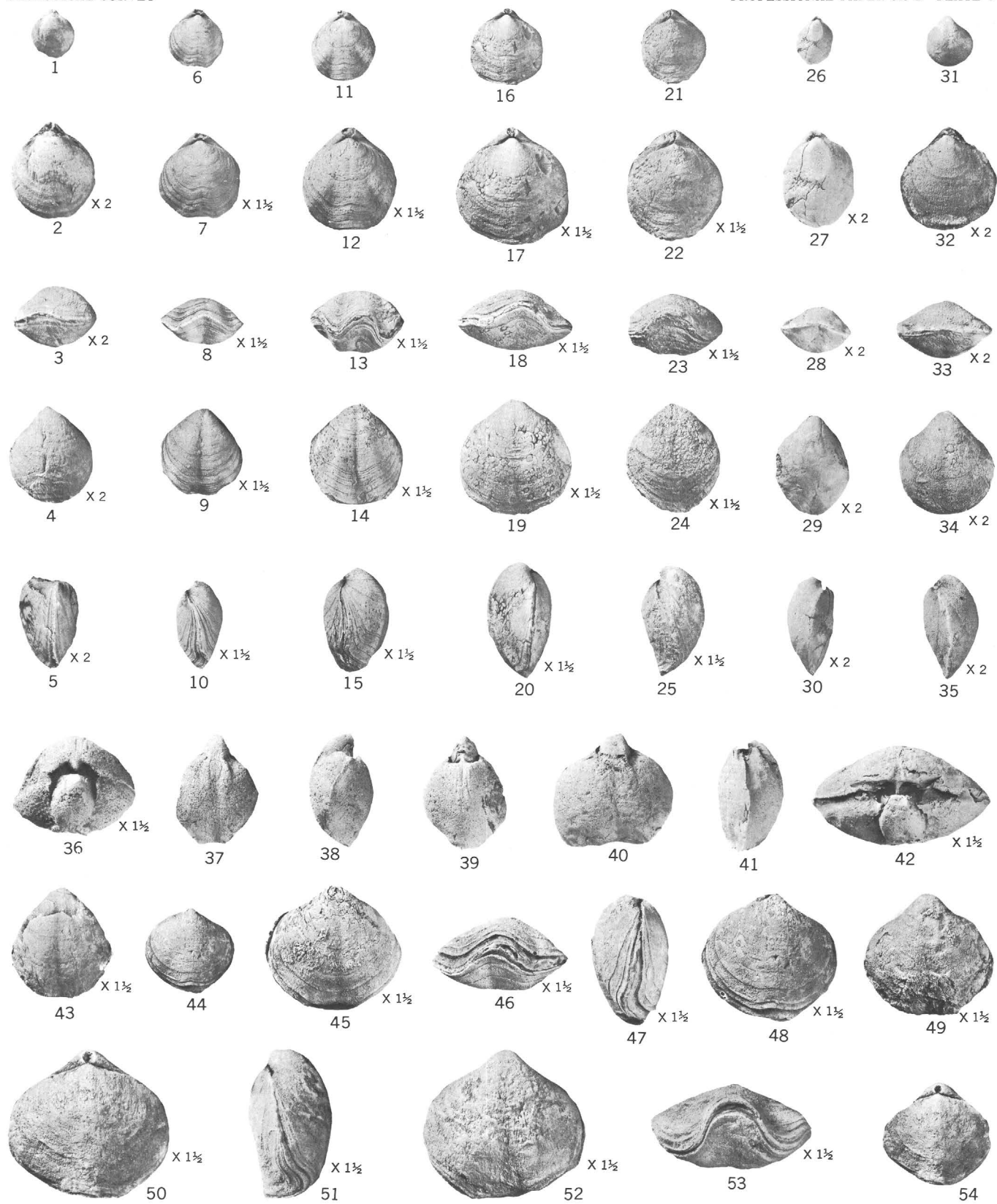
## PLATE 8

[Figures natural size unless otherwise indicated on plate]

### FIGURES

- 1-5, 43. *Composita* aff. *C. laevis* Weller (p. D58).  
 From Horseshoe Shale Member.  
 1-5. Brachial view and enlarged brachial, anterior, pedicle, and side views of small specimen, USNM 168396, from Horseshoe Shale Member, collection 118.  
 43. Enlarged ventral view of pedicle valve, USNM 168397, from Horseshoe Shale Member, collection 117.
- 6-20. *Composita poposiensis* n. sp. (p. D61).  
 From Horseshoe Shale Member.  
 6-15. Brachial view and enlarged brachial, anterior, pedicle, and side views of two paratypes, USNM 168408, 168407, collection 38.  
 16-20. Brachial view and enlarged brachial, anterior, pedicle, and side views of broad depressed variant, paratype, USNM 168404, collection A.
- 21-25, 36-39. *Composita sigma* n. sp. (p. D59).  
 From Horseshoe Sale Member.  
 21-25. Brachial view and enlarged brachial, anterior, pedicle, and side views of paratype, USNM 168412, collection 47.  
 36-39. Enlarged posterior view and pedicle, side, and brachial views of internal mold, USNM 168454, collection B.
- 26-30. *Composita sigma* n. sp? (p. D60).  
 Dorsal view and enlarged dorsal, anterior, ventral and side views of specimen, UM 2652, described by Branson and Greger (1918) as *Martinia* n. sp., from Horseshoe Shale Member, collection 36a.
- 31-35, 49. *Composita subquadrata* (Hall) (p. D59).  
 31-35. Brachial view and enlarged brachial, anterior, pedicle, and side views of immature specimen, USNM 168431, from Horseshoe Shale Member, collection 41.  
 49. Enlarged ventral view of pedicle valve, USNM 168430, collection 41.
- 40-42, 44-48, 50-54. *Composita sulcata* Weller (p. D62).  
 From Horseshoe Shale Member.  
 40-42. Pedicle, side, and enlarged posterior views of internal mold, USNM 168455, collection 36e.  
 44-48. Brachial view and enlarged pedicle, anterior, side, and brachial views of specimen, USNM 168424, collection A.  
 50-54. Enlarged brachial, side, pedicle, and anterior views and brachial view of another specimen, USNM 168423, collection A.





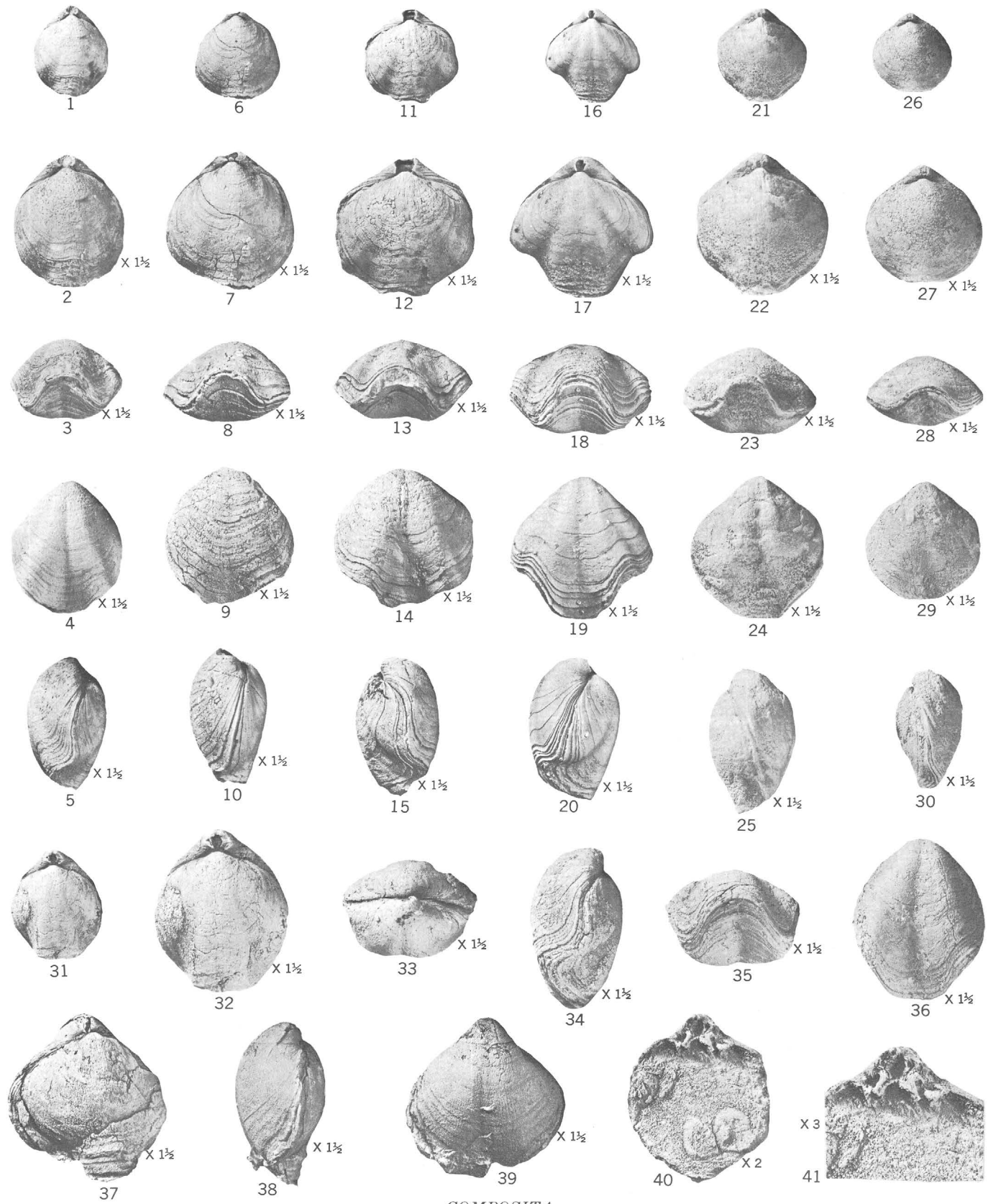
COMPOSITA



## PLATE 9

[Figures natural size unless otherwise indicated on plate]

- FIGURES 1-15, 31-36. *Composita poposiensis* n. sp. (p. D61).  
From Horseshoe Shale Member.  
1-5. Brachial view and enlarged brachial, anterior, pedicle, and side views of paratype, USNM 168403, collection A.  
6-15. Brachial view and enlarged brachial, anterior, pedicle, and side views of two variant paratypes, USNM 168409, and 168406, collection 38.  
31-36. Brachial view and enlarged brachial, posterior, side, anterior, and pedicle views of the holotype, USNM 168400, collection B.
- 16-20. *Composita trinuclea* (Hall) (p. D62).  
Brachial view and enlarged brachial, anterior, pedicle, and side views of well-preserved specimen, USNM 168422, from "Pella Beds," 4½ miles south of Pella, Iowa. Included for comparison.
- 21-30. *Composita sigma* n. sp. (p. D59).  
From Horseshoe Shale Member.  
21-25. Brachial view and enlarged brachial, anterior, pedicle, and side views of paratype, YPM 5154b, collection 44.  
26-30. Brachial view and enlarged brachial, anterior, pedicle, and side views of holotype, USNM 168411, collection 47.
- 37-41. *Composita subquadrata* (Hall) (p. D59).  
37-39. Enlarged brachial, side, and pedicle views of specimen, USNM 168429, from Horseshoe Shale Member, collection 41.  
40, 41. Enlarged view and enlarged partial view of poorly preserved pedicle valve interior articulate with hinge plate of brachial valve, USNM 168432, collection 41.

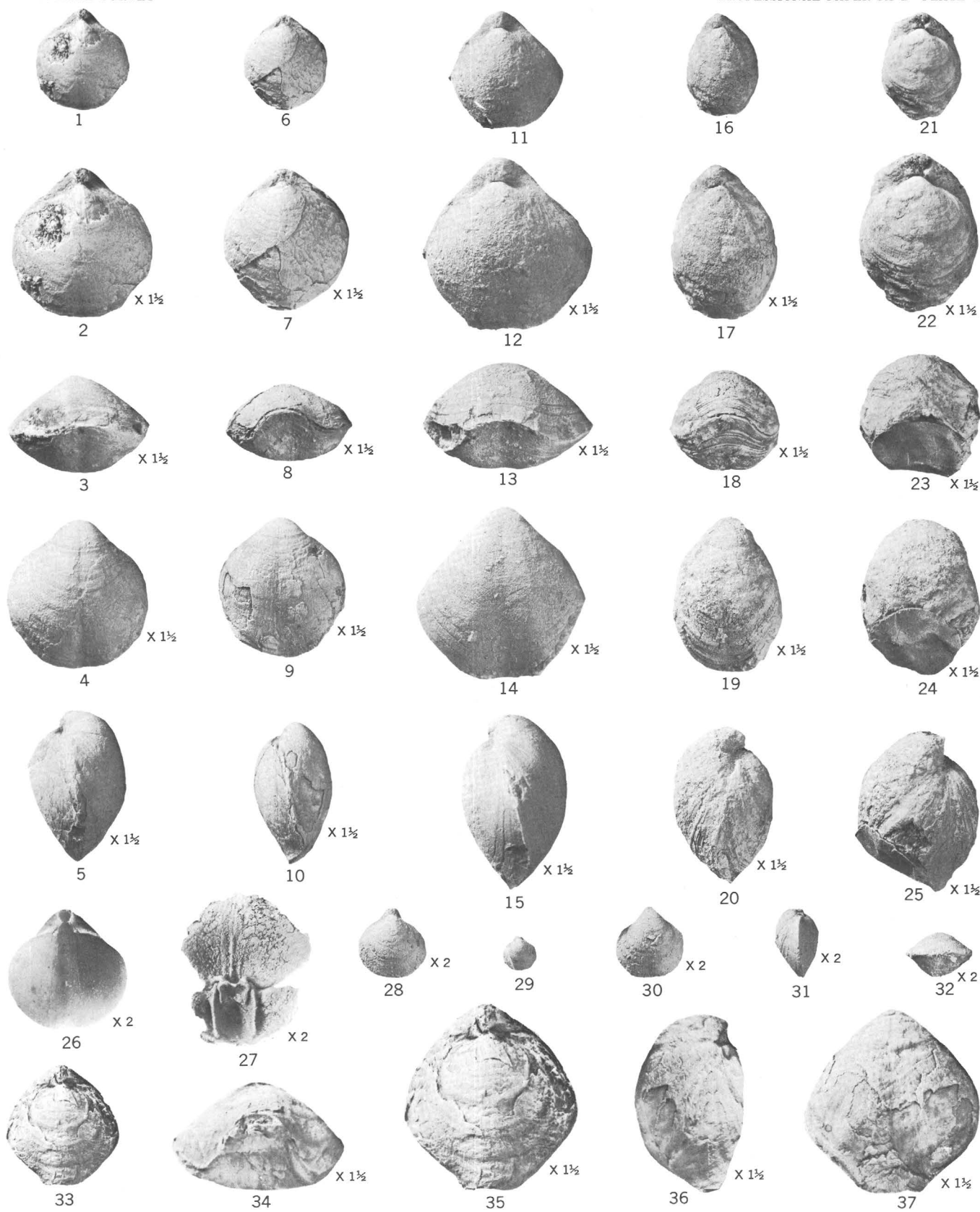


COMPOSITA

## PLATE 10

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- FIGURES 1-15, 26-32. *Composita ovata* Mather (p. D63).
- 1-10. Brachial view and enlarged brachial, anterior, pedicle, and side views of two specimens, USNM 168438, 168439, from Horseshoe Shale Member, collection 3.
  - 11-15. Brachial view and enlarged brachial, anterior, pedicle, and side views of moderately large shell, USNM 168434, from Ranchester Limestone Member, collection 14.
  - 26. Enlarged view of interior of silicified pedicle valve, USNM 168436, collection 14.
  - 27. Enlarged view of another silicified incomplete shell showing articulation of pedicle and brachial valves, USNM 168437, collection 14.
  - 28-32. Enlarged brachial view, brachial view, and enlarged pedicle, side, and anterior views of immature shell, USNM 168435, collection 14.
- 16-25. *Composita elongata* Dunbar and Condra (p. D64).
- Brachial view and enlarged brachial, anterior, pedicle, and side views of two specimens, USNM 168441, 168440, from Horseshoe Shale Member, collection 3.
- 33-37. *Composita subtilita* (Hall) (p. D64).
- Brachial view and enlarged anterior, brachial, side, and pedicle views of specimen, USNM 168433, collection 136.

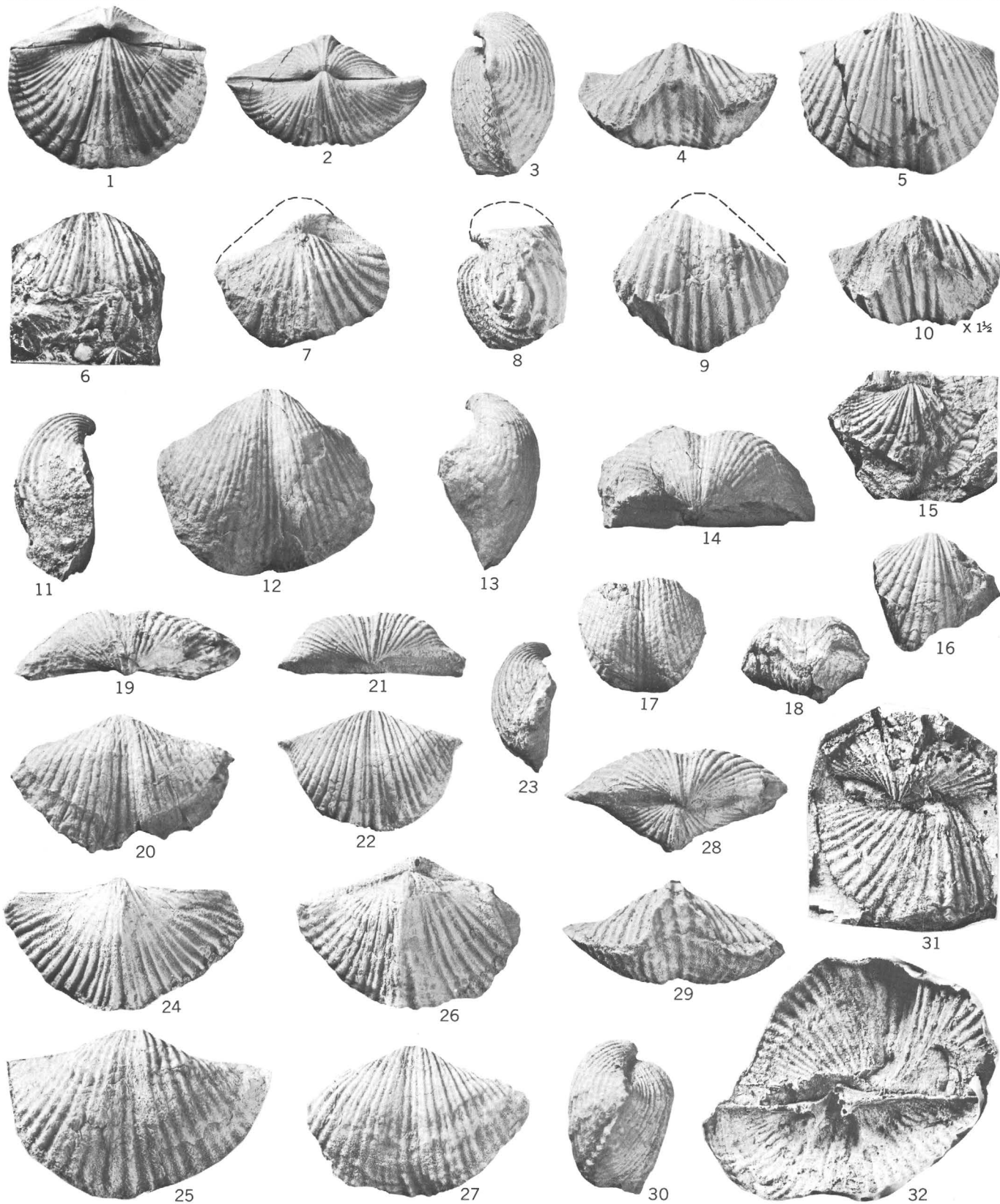


COMPOSITA

## PLATE 11

[Figures natural size unless otherwise indicated on plate]

- FIGURES 1-5. *Anthracospirifer curvilateralis curvilateralis* (Easton) (p. D65).  
 Brachial, posterior, side, anterior, and pedicle views of topotype, USNM 167735, from Heath Formation, Big Snowy Mountains, Mont., USGS collection 16184-PC.
- 6-12. *Anthracospirifer curvilateralis brutus* n. subsp. (p. D66).  
 6, 12. Ventral and side views of pedicle valve, paratype, USNM 167741, from Horseshoe Shale Member, collection 117.  
 7-10. Brachial, side, pedicle, and anterior views of holotype, USNM 167736, from Moffat Trail Limestone Member, collection 79.  
 11. Dorsal view of brachial valve, paratype, USNM 167742, collection 117.
- 13-18. *Anthracospirifer rawlinsensis* n. sp. (p. D69).  
 From Horseshoe Shale Member.  
 13-15. Ventral, side, and posterior views of large pedicle valve, holotype, USNM 167747, collection 3.  
 16. Enlarged dorsal view of part of brachial valve, paratype, USNM 167748, collection 3.  
 17, 18. Pedicle and anterior views of slender incomplete specimen, USNM 167753, collection 4.
- 19, 20. *Anthracospirifer* aff. *A. occiduus* (Sadlick), form A (p. D68).  
 Posterior and ventral views of pedicle valve, USNM 167745, from Horseshoe Shale Member, collection 153.
- 21-23. *Anthracospirifer* aff. *A. occiduus* (Sadlick), form B (p. D69).  
 Posterior, ventral, and side views of pedicle valve, USNM 167746, from Ranchester Limestone Member, collection 146.
- 24-32. *Anthracospirifer occiduus* (Sadlick) (p. D67).  
 24. Dorsal view of brachial valve, paralectotype, USNM 118717C, from Wells Formation, Webster Range, Idaho, USGS collection 32-PC.  
 25. Ventral view of pedicle valve, another paralectotype, USNM 118717B, from same collection.  
 26-30. Brachial, pedicle, posterior, anterior, and side views of lectotype, USNM 118717A, same collection.  
 31, 32. Latex casts of exterior and interior of brachial and pedicle valve belonging apparently to same specimen, hypotype, USNM 167744, from Ranchester Limestone Member, collection 131.



*ANTHRACOSPIRIFER*

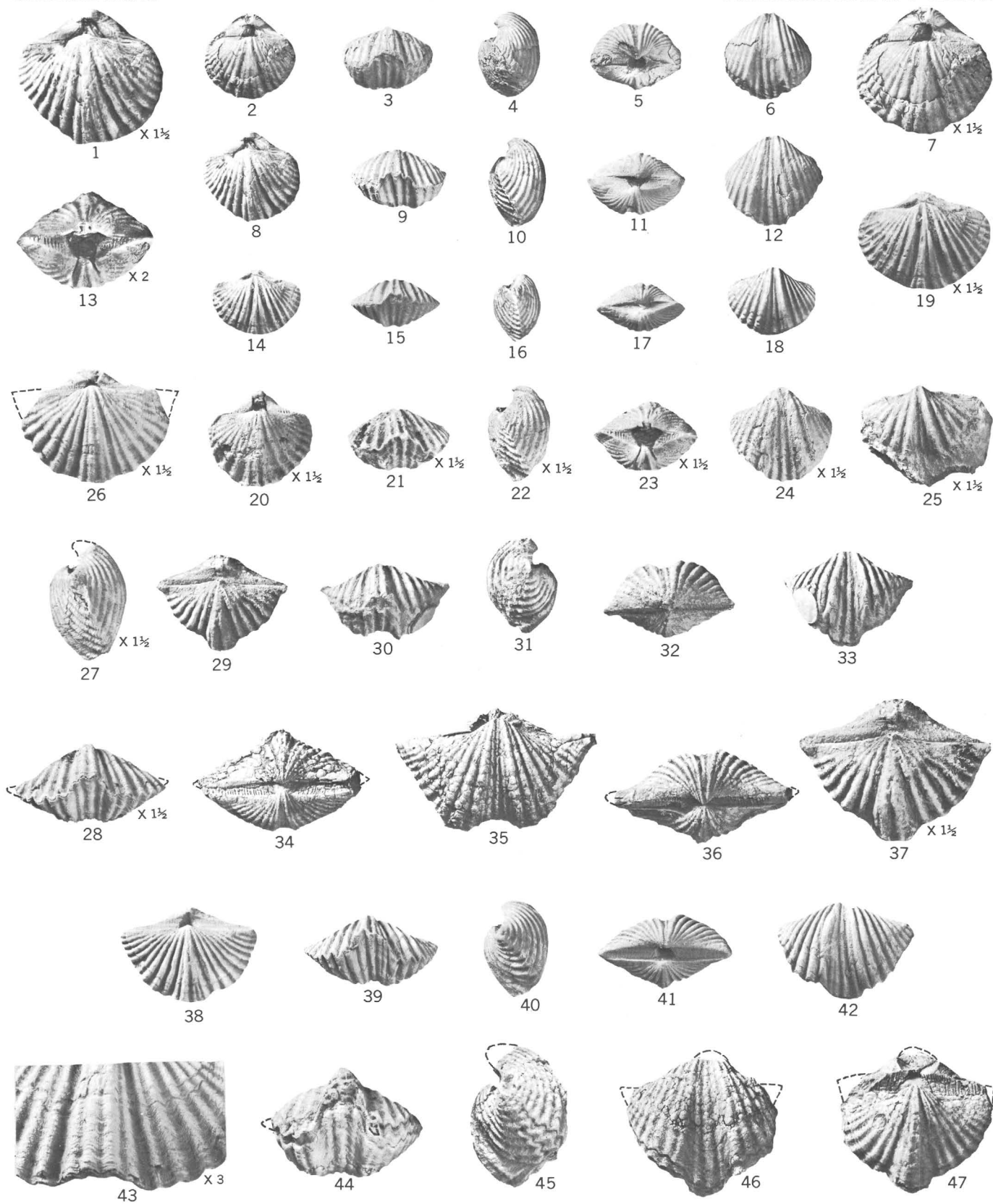
## PLATE 12

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### FIGURES

- 1-24. *Anthracospirifer welleri welleri* (Branson and Greger) (p. D72).  
From Horseshoe Shale Member.
  - 1, 8-12. Enlarged brachial view, brachial, anterior, side, posterior, and pedicle views of paralectotype, UM 3532, collection 36b.
  - 2-7. Brachial, anterior, side, posterior, and pedicle views and enlarged brachial view of lectotype, UM 3532, collection 36b.
  - 13, 20-24. Enlarged posterior, brachial, anterior, side, posterior, and pedicle views of internal mold, hypotype, UW IT-201, illustrated by Burk (1954) as *Spirifer opimus* Hall, collection 22.
  - 14-19. Brachial, anterior, side, posterior, and pedicle views and enlarged brachial view of moderately transverse specimen, paralectotype, UM 3532, collection 36b.
- 25, 29-33, 37-42. *Anthracospirifer shawi shawi* n. subsp. (p. D70).  
From Horseshoe Shale Member.
  25. Poorly preserved pedicle valve, USNM 167758, collection 137.
  - 29-33, 37. Brachial, anterior, side, posterior, and pedicle views and enlarged brachial view of holotype, UM 2651B, figured by Branson and Greger (1918) as *Spirifer pellaensis* Weller, collection 36b.
  - 38-42. Brachial, anterior, side, posterior, and pedicle views of well-preserved paratype, USNM 167757, collection F.
- 26-28, 34-36, 43-47. *Anthracospirifer shawi exoletus*, n. subsp. (p. D71).  
From Horseshoe Shale Member.
  - 26-28, 43. Enlarged brachial, side, and anterior views and anterior view showing micro-ornament, paratype, UW IT-205, figured by Burk (1954) as *Spirifer opimus* (Hall), collection 35. Cardinal extremities restored.
  34. Posterior view of silicified specimen, paratype, USNM 167755, from collection 38.
  35. Pedicle view of holotype, UM 2651A, figured by Branson and Greger (1918) as *Spirifer pellaensis* Weller, collection 36b.
  36. Posterior view of paratype, UM 3533, also figured by Branson and Greger (1918) as *Spirifer pellaensis* Weller, collection 36a.
  - 44-47. Anterior, side, pedicle, and brachial views of silicified specimen lacking parts of beak and cardinal extremities, restored, paratype, USNM 167754, collection 38.





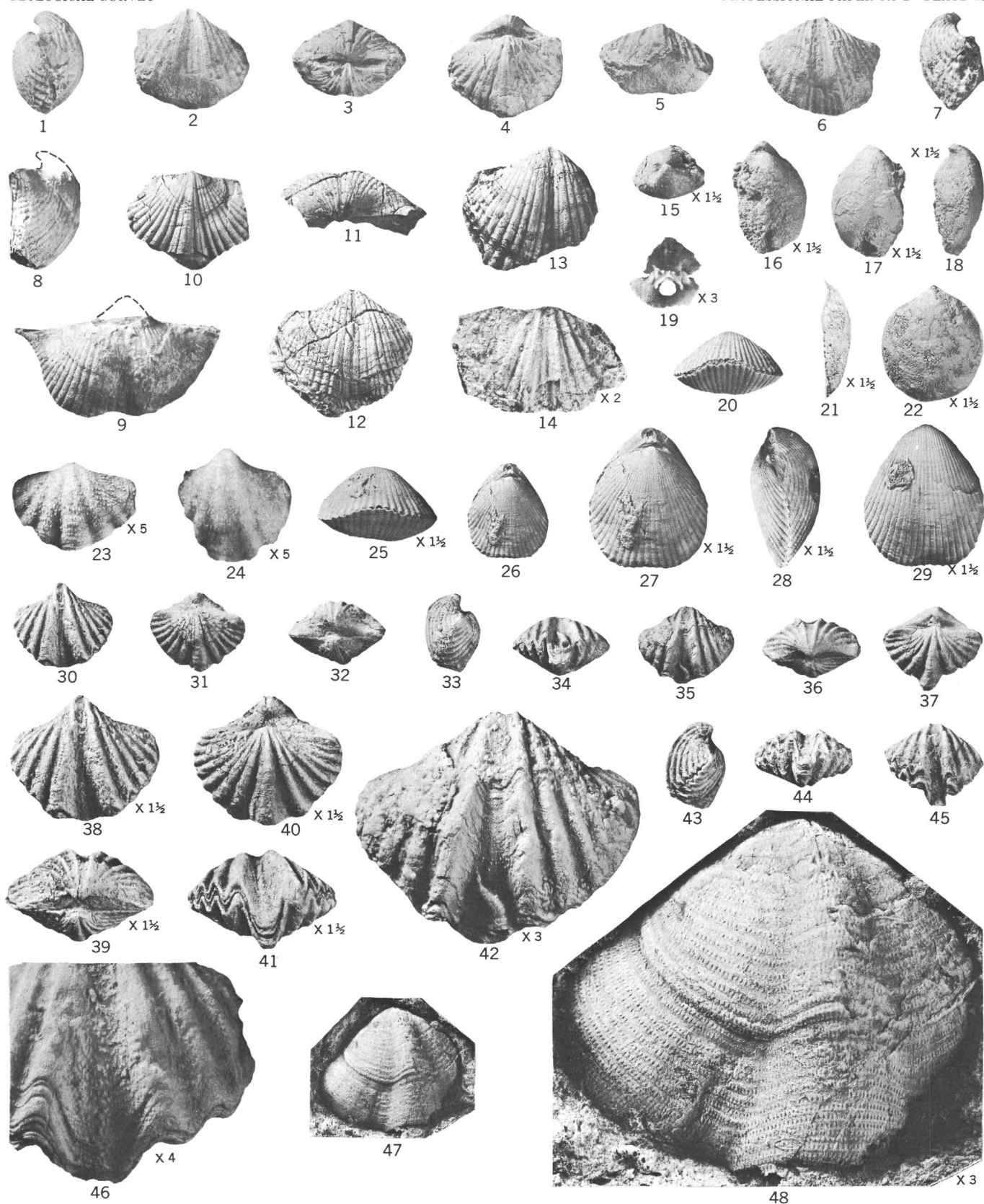
ANTHRACOSPIRIFER

# PLATE 13

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## FIGURES

- 1-7. *Anthracospirifer welleri lincolnensis* n. subsp. (p. D73).
  - 1-5. Side, pedicle, posterior, brachial, and anterior views of holotype, USNM 167759, from Ran-  
chester Limestone Member, collection 82.
  - 6, 7. Ventral and side views of pedicle valve, paratype, USNM 174031, collection 82.
- 8-13. *Brachythyridina washakiensis* n. sp. (p. D74).
  - From Horseshoe Shale Member, collection 41.
  - 8, 9. Side and ventral views of pedicle valve, holotype, USNM 167760. Umbonal area restored.
  10. Incomplete brachial valve, USNM paratype 167763.
  - 11, 12. Posterior and ventral views of pedicle valve, paratype, USNM 167761.
  13. Ventral view of another pedicle valve, paratype, USNM 16772.
14. *Neospirifer praeununtius* Easton (p. D75).
  - Fragment of umbonal area of pedicle valve, showing fasciculation of costae, USNM 166764, from  
Moffat Trail Limestone Member, collection 120.
- 15-18, 21, 22. *Girtyella* cf. *G. indianensis* (Girty) (p. D78).
  - From Horseshoe Shale Member.
  - 15-18. Enlarged posterior, brachial, pedicle, and side views of partly distorted specimen, UM  
10890, collection 36d.
  - 21, 22. Enlarged side and dorsal views of brachial valve, UW A11118, collection 28.
- 19, 20, 25-29. *Eumetria sulcata* Burk (p. D77).
  - From Horseshoe Shale Member.
  19. Fragment of interior of beak area showing pedicle opening and articulation of both valves,  
USNM 168458, collection 69.
  20. Anterior view of moderately large individual, USNM 168457, collection 38.
  - 25-29. Enlarged anterior view, brachial view, and enlarged brachial, side, and pedicle views of  
holotype, UW IT-231, collection 35.
- 23, 24, 30-46. *Reticulariina browni* (Branson and Greger) (p. D75).
  - From Horseshoe Shale Member.
  23. Enlarged dorsal view of brachial valve, showing details of spine arrangement, hypotype,  
USNM 168445, collection 69.
  24. Enlarged ventral view of pedicle valve, showing similar details, hypotype, USNM 168444, col-  
lection 69.
  - 30, 38-41. Pedicle view and enlarged pedicle, posterior, brachial, and anterior views of hypo-  
type, USNM 168442, collection 27.
  - 31-35, 42. Brachial, posterior, side, anterior, and pedicle views and enlarged pedicle view, show-  
ing minute spines and punctae, lectotype, UM 2656, bearing attached *Cornulitella* figured by  
Branson and Greger as *Ortonia* cf. *O. blatchleyi* Beede, collection 36b.
  - 36, 37, 43-45. Posterior, brachial, side, anterior, and pedicle views of paralectotype, UM 2650,  
collection 36c.
  46. Enlargement of anterior part of pedicle valve, showing arrangement of fine spines that pro-  
trude through thin limonitic coating, hypotype USNM 168443, collection 27.
- 47, 48. *Torynifer setiger* (Hall)? (p. D65).
  - Dorsal view and enlarged dorsal view of latex cast of brachial valve, USNM 168456, from Horse-  
shoe Shale Member, collection 45.



ANTHRACOSPIRIFER, BRACHYTHYRINA, NEOSPIRIFER, GIRTYELLA,  
EUMETRIA, RETICULARIINA, AND TORYNIFER



