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CONTRIBUTIONS

TO THE

CRETACEOUS PALEONTOLOGY OF THE PACIFIC COAST

THE FAUNA OF THE KNOXVILLE BEDS

BY

TIMOTHY WILLIAM STANTON



WASHINGTON
GOVERNMENT PRINTING OFFICE
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, May 30, 1895.

SIR: I have the honor to transmit herewith a paper entitled "Contributions to the Cretaceous Paleontology of the Pacific Coast: The Fauna of the Knoxville Beds." The introductory portion consists of a geological description of the Lower Cretaceous Aucella-bearing series of the Pacific States, with a discussion of its age and of its relations with various other formations characterized by a similar fauna.

The body of the paper is devoted to the description and illustration of the invertebrate fauna of the Knoxville, in which 77 distinct species and varieties are recognized and 50 species are described as new.

Very respectfully,

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Hon. C. D. WALCOTT,
Director United States Geological Survey.



CONTRIBUTIONS TO THE CRETACEOUS PALEONTOLOGY OF THE PACIFIC COAST: THE FAUNA OF THE KNOXVILLE BEDS.

BY TIMOTHY W. STANTON.

INTRODUCTION.

DEFINITION OF THE KNOXVILLE BEDS.

Previous to the publication in 1869 of Vol. II, Palæontology of California, the deposits on the Pacific Coast now recognized as Cretaceous were not divided into groups or formations. In that volume Professors Whitney and Gabb gave the name Shasta group to the complex series of Lower Cretaceous beds which they recognized to be of different ages, probably from the Neocomian to the Gault, inclusive. They also proposed the names Chico group, Martinez group, and Tejon group for the beds overlying the Shasta in the order named. Of these the Tejon is now generally believed to be of Eocene age, and the Cretaceous portion of the ill-defined and heterogeneous Martinez group is inseparable from the Chico.

In 1885 Dr. C. A. White¹ and Dr. G. F. Becker¹ recognized two divisions of the Shasta formation, which they called the Knoxville beds and the Horsetown beds. The former, which is especially characterized by the abundant occurrence of *Aucella*, was named from the village of Knoxville, in the quicksilver mining district of Napa County, Cal., where it is well developed, while the typical localities of the Horsetown beds, characterized by a different fauna, rich in ammonites, were given as the north fork of Cottonwood Creek and Horsetown, in Shasta County.

Although at that time the stratigraphic relations of these two divisions were not known, and they had not even been seen in adjacent areas, subsequent more detailed studies have confirmed the opinions then expressed, both as to the position of the Knoxville beneath the Horsetown and as to the limits between the two. It is true that they have been found to be much more closely connected, both faunally and stratigraphically, than was then supposed, but wherever they have been seen in contact the upper limit of the range of *Aucella* has proved to be the most natural and convenient line of separation between the

¹Bulls. U. S. Geol. Surv. Nos. 15 and 19. The divisions were again defined by Dr. Becker, in Mon. U. S. Geol. Surv. Vol. XIII.

two divisions,¹ and the base of the section on the north fork of Cottonwood Creek practically coincides with the base of the Horsetown beds.

The Knoxville may be briefly defined, therefore, as the Aucella-bearing Cretaceous beds on the Pacific Coast of the United States.

GEOGRAPHIC DISTRIBUTION.

Although it is a well-known fact that beds strictly equivalent with the Knoxville occur in British Columbia, and probably in Alaska, Mexico, and more distant regions, it is thought best to limit the present description and discussion of the fauna to species collected within the United States and at localities where the stratigraphic relations are fairly well established. As thus restricted, the Knoxville beds are confined to the coast ranges of California, Oregon, and Washington, where they have been recognized by the presence of Aucella at many localities, from Santa Margarita, San Luis Obispo County, Cal. (a little north of latitude 35°), on the south, to the neighborhood of Seattle, Wash., on the north. Some of the more important localities will be described below.

STRATIGRAPHIC RELATIONS.

The upper limit of the Knoxville beds has already been mentioned. Where the series is complete, as in Tehama County, Cal., the Knoxville is conformably overlain by the Horsetown beds, with a varied and abundant fauna. The lower limit is more difficult to define, because the base is usually either concealed by the intrusion of eruptive rocks or rests on metamorphic rocks of undetermined age. Massive dikes of serpentine (occasionally unaltered peridotite) are very frequently associated with the Lower Knoxville beds throughout the entire area of their occurrence. On the Cold fork of Cottonwood Creek, Tehama County, the underlying rocks include crystalline limestone of probable Carboniferous age.² Opinions have differed as to the age of the metamorphic rocks associated with the Lower Knoxville in the areas farther south, some authors, as Whitney, and more recently Becker, holding that they are only altered portions of the Cretaceous beds, while others have thought that they are of pre-Cretaceous age. The latter view has been maintained especially by Mr. H. W. Fairbanks in a number of papers published in 1892 to 1894. One of the latest³ of these summarizes the arguments for the pre-Cretaceous age of these rocks. The evidence of an unconformity between them and the Knoxville, striking differences in the lithological character of the sediments, and the absence of the Knoxville fauna are the main points advanced to prove

¹Practically the same divisions were recognized by Mr. J. F. Whiteaves, in an article "On the Lower Cretaceous Rocks of British Columbia," published in *Trans. Royal Soc. of Canada*, Vol. I, sec. 4, pp. 81-86, 1882. He did not give a name to the lower division, however, and in his later publications he has denied the validity of the divisions then made, so far as they apply to the Cretaceous of British America.

²Diller and Stanton, *The Shasta-Chico Series*, *Bull. Geol. Soc. Am.*, Vol. V, p. 442.

³Review of our knowledge of the Geology of the California Coast Ranges, *Bull. Geol. Soc. Am.*, Vol. VI, pp. 71-102, 1894.

the thesis. These supposed pre-Cretaceous beds have yielded very few definite fossils. At Slates Springs, Monterey County, Mr. Fairbanks obtained a large species of *Inoceramus*¹ and a few other forms, none of which is referable to Knoxville species, though the *Inoceramus* is related to *I. quatsinoensis* Whiteaves from the Aucella-bearing Cretaceous of Vancouver Island. *Inoceramus ellioti* Gabb, from the "San Francisco sandstone" on Alcatraz Island, is also referred to this pre-Cretaceous series by Fairbanks, and a few other indeterminate fossils have been obtained from the same beds in the neighborhood of San Francisco. Cherts interbedded with the San Francisco sandstone contain abundant, but badly preserved, radiolarian remains.² The paleontological evidence, though meager, indicates that these beds, as well as those at Slates Springs, are not older than Jurassic, but it is not sufficient to fix their age more definitely. While it seems probable that they underlie the Knoxville beds and are unconformable with them, no section has yet been described in which their stratigraphic relations may be clearly seen.

We may say, then, that the Knoxville beds rest on strata of different ages, from the Carboniferous to probable Upper Jurassic, and that they are unconformable on the underlying strata at some places, and probably everywhere.

LITHOLOGIC CHARACTER.

Dark clay shales greatly predominate over all other kinds of rocks in the Knoxville beds, but there is also considerable sandstone, usually in thin beds. In some places the lower part of the formation consists of alternations of shale and sandstone, or calcareous material, in bands only a few inches thick. There are also occasional thicker beds of sandstone, and sometimes massive conglomerates. The larger bodies of shale frequently contain many calcareous concretions, and such concretions are sometimes found even in the coarse conglomerates. More rarely there are larger bodies of limestone, several feet in thickness, but they do not form continuous beds of any great extent. For example, the limestone 3 miles northwest of Paskenta, which has yielded a number of the fossils described in this paper, is only about 100 feet long. The one near Wilbur Springs, Colusa County, may be traced for about one-fourth mile. The conglomerates also appear to be local deposits of no great length, though sometimes of very considerable thickness.

LOCAL DEVELOPMENT.

TEHAMA COUNTY, CAL.

The area on the west side of the Sacramento Valley, extending southward from the north fork of Cottonwood Creek, through Shasta and Tehama counties, shows a better development of the Lower

¹ Op. cit., p. 93. See also 12th Rept. Cal. State Mining Bureau, p. 519, 1894.

² F. L. Ransome, Geology of Angel Island, with a note on the Radiolaria by Dr. G. J. Hinde, Bull. Geol. Dept. Univ. of Cal., Vol. I, pp. 193-240.

Cretaceous, both faunally and stratigraphically, than any other region yet studied in California. Its principal features have been described by Mr. J. S. Diller¹ and the present writer² in several papers, from which the following notes are condensed. The object is not to give a full geological description of the areas described, but to give enough to show the associations and stratigraphic relations of the fossils described. In the lists of species from the Knoxville beds the nomenclature is revised in accordance with that adopted in the body of this paper, and whenever there are changes or omissions from lists from the same localities, published in earlier papers, the present lists are to be regarded as more nearly correct.

The most northerly point in Sacramento Valley at which the Knoxville fauna has been found is at Stephenson's, on the Cold fork of Cottonwood Creek, Tehama County. It is certain, however, that the Knoxville beds continue some miles farther north, for their thickness here, as estimated by Mr. Diller, is about 10,000 feet, though they do not extend as far as Ono, some 25 miles north, where the Horsetown beds rest directly on metamorphic rocks. The 10,000 feet of Knoxville beds in the Cold fork section consist of dark crumpled shales with thin calcareous and sandy bands, and several heavy local beds of coarse conglomerate, the whole resting unconformably on metamorphic rocks of probably Carboniferous age. The basal bed at one place is a coarse conglomerate, and at another point in the same neighborhood it is a shale. The strata all have a steep dip, often nearly or quite vertical.

The only fossils found were in the upper part of the Knoxville. Near Stephenson's house *Aucella crassicollis* is quite abundant, and almost on the strike of this bed, five-eighths of a mile up a small ravine that comes in from the northwest, some thin, slightly calcareous layers yielded the following species:

Pentacrinus sp.	<i>Leda glabra.</i>
Rhynchonella sp.	<i>Opis californica.</i>
Terebratella californica.	<i>Cyprina occidentalis.</i>
Terebratula sp.	<i>Astarte californica.</i>
Ostrea sp. cf. skidegatensis.	<i>Solecrtus ? dubius.</i>
Lima multilineata.	<i>Corbula filosa.</i>
Pecten californicus?	<i>Helcion granulatus.</i>
Spondylus fragilis.	<i>Fissurella bipunctata.</i>
<i>Aucella crassicollis.</i>	<i>Pleurotomaria sp.</i>
<i>Myoconcha americana.</i>	<i>Turritella sp.</i>
<i>Arca textrina.</i>	<i>Cerithium sp.</i>
<i>Pectunculus ? ovatus.</i>	<i>Belemnites impressus.</i>

The beds overlying the Knoxville here form a continuous section up to and including the Chico, but it was not studied in detail and only a few fossiliferous horizons were found. One of these is a limestone, believed to be within the Horsetown beds, a half mile or more across the strike from the *Aucella* locality. It yielded numerous specimens

¹Am. Jour. Sci. (3), Vol. XL, 1895, p. 476; Bull. Geol. Soc. Am., Vol. II, p. 207; vol. 4, pp. 205-224; vol. 5, pp. 435-464 (the last a joint paper).

²Bull. Geol. Soc. Am., Vol. IV, pp. 245-256.

of *Modiola major*, *Fusus* ? sp., and a few examples of a *Lucina* ? and an *Olcostephanus* related to *O. deansii* Whiteaves.

On Elder Creek, 15 miles south of the Cold fork of the Cottonwood, Messrs. J. S. Diller¹ and J. Stanley-Brown have measured a section that shows the enormous thickness of 30,000 feet of Cretaceous strata, of which about 20,000 feet are assigned to the Knoxville. The following descriptive notes on this section are by Mr. Diller²:

In the Knoxville beds shales predominate, although there are a large number of thin sandstones interstratified with the shales. The great majority of these sandstones are less than a foot in thickness, and they rarely, if ever, attain 10 feet along the north fork of Elder Creek. Sandstones are most abundant in the lower half of the Knoxville; in the upper half they are uncommon. Both north and south of Elder Creek the Knoxville beds contain thick strata of conglomerate, which do not appear in the measured section. The base of the section is serpentine, which has resulted from the alteration of an eruptive rock, in all probability belonging to the peridotites. Ripple marks have been found in this portion of the section, showing that the rocks were deposited in shallow water.

The shales of the Knoxville beds, with occasional thin layers of sandstone, continue upward without any interruption either in the character of the sediments or in the position of the strata into the Horsetown beds. On account of the gradual transition in all respects from the Knoxville to the Horsetown beds, it is impossible to draw a sharp line between them. *Aucella* being the most abundant, widely distributed, and characteristic fossil of the Knoxville beds, it seems best to draw the line upon a paleontological basis at the upper limits of the *Aucella*-bearing layers. At that horizon fossils are usually abundant.

The Horsetown beds [about 6,000 feet thick] in this section are composed chiefly of shales, although there are some sandstones of considerable size. One was observed 50 feet in thickness, another 12 feet, and a third 8 feet. Few fossils were found in these beds along Elder Creek, but a short distance to the southward, in the Bald Hills, immediately above the Knoxville, they are more fossiliferous. Several miles east of Lowreys, on Elder Creek, the basal portion of the Chico is rich in fossils. Here is found an intermingling of numerous Chico and Horsetown forms.

The Chico, which has a thickness of nearly 4,000 feet in this section, is composed chiefly of sandstones and conglomerates. The basal portion is made up of conglomerates altogether. The upper portion for 1,100 feet is composed chiefly of shales, and there are some shales lower down intercalated between the sandstones and conglomerates. The conglomerates at the base contain numerous nodules of limestone which are rich in fossils.

Few fossils were found in either the Knoxville or the Horsetown along the line of the measured section. About 5,000 feet above the base of the section the typical variety of *Aucella piochii* is abundant, and some 8,000 feet higher the following fossil plants, identified by Prof. W. M. Fontaine, were collected:

Angiopteridium canmorensis (?).
Glossozamites klipsteini.
Pecopteris strictinervis (?).
Thyrsopteris rarinervis (?).
Nageiopsis longifolia (?).
Sagenopteris sp.
Cephalotaxopsis sp.
Cladophlebis inclinata (?).

Osmunda dicksonoides (?).
Angiopteridium strictinerve (?).
Angiopteridium nervosum (?).
Aspidium dunkeri (?).
Aspidium heterophyllum.
Aspleniopteris pinnatifida (?).
Thinnfeldia variabilis (?).

¹Am. Jour. Sci. (3), Vol. XL, p. 476; republished in somewhat detailed form, with lists of fossils, in Bull. Geol. Soc. Am., Vol. V, pp. 439-440.

²Bull. Geol. Soc. Am., Vol. V, pp. 440-441.

The collection was not large and the material was not very well preserved; consequently few positive identifications could be made. The species to which they are doubtfully referred are all from the Lower Cretaceous.

Higher in the Knoxville, 4,000 to 5,000 feet above the plant horizon, *Lytoceras batesi*, *Desmoceras* sp., and *Belemnites impressus* were collected.

No thoroughly characteristic Horsetown species were obtained in the section, but in the lower 1,500 feet of the Chico the following species were collected:

Pecten operculiformis.	Thetis annulata.
Exogyra parasitica.	Tellina ashburneri.
Cucullæa truncata.	Tellina parilis.
Nemodon vancouverensis.	Dentalium stramineum.
Pectunculus veatchi.	Lunatia avellana.
Trigonia evansana.	Gyrodes expansa.
Trigonia leana.	Anchura falciformis.
Meekia sella.	Anchura californica.
Coralliochama orcutti.	Cinulia matthewsoni.
Chione varians.	Actæon inornatus.
Caryatis nitida.	Desmoceras jugale ?

A still higher horizon yielded *Inoceramus whitneyi* and *Pachydiscus neuberryanus*.

The Horsetown and the Knoxville are both much better represented paleontologically just south of the section in the area extending from the north fork of Elder Creek to Paskenta, a distance of 10 miles. A large proportion of the species described beyond are from this area, which may really be regarded as a part of the Elder Creek section, since the general strike of the beds is nearly north and south, and some of the horizons may be easily traced for long distances. On the south fork of Elder Creek, near Cooper's, which is about 5 miles southwest of Lowrey's and not more than 4 miles south of the measured section, there are good exposures of the strata 2,000 to 3,000 feet below the top of the Knoxville. Calcareous bands and concretions in the shales at the lower horizon mentioned contain numerous specimens of *Aucella piochii*, with occasional specimens of *A. piochii* var. *ovata* and an abundance of fossil wood. There were also obtained here *Pecten* sp., *Lucina ovalis* (?), *Hoplites storrsi*, *Phylloceras knoxvillensis*, fragments of *Lytoceras batesi*, or a closely related species, and *Belemnites*. A little higher in the same section a heavy bed of sandstone, forming a high ridge, yielded *Aucella piochii* and variety with imperfect specimens of a *Perisphinctes*. In the overlying shales, about 1,000 feet above the horizon of *Hoplites storrsi*, *Aucella piochii* var. *ovata* and *Belemnites tehamaensis* are abundant. *Aucella crassicollis* and *Inoceramus ovatus* were collected here also; *Hoplites dilleri* comes from near this horizon—perhaps a little lower—some 3 miles to the northward.

The locality 3 miles northwest of Paskenta, which will be frequently mentioned in the descriptions of species, is 4 or 5 miles south of Cooper's

and on approximately the horizon from which *Hoplites storrsi*, *Phylloceras knoxvillensis*, etc., were obtained. Here, in the midst of shales with *Aucella piochii*, there is a mass of limestone about 10 feet thick and not much more than 100 feet long. It has yielded the following species:

Rhynchonella schucherti.	Solemya occidentalis.
Aucella piochii.	Corbula persulcata.
Aucella piochii var. ovata.	Turbo paskentaensis.
Nucula gabbi.	Amberleya dilleri.
Nucula storrsi.	Hypsipleura occidentalis.
Lucina ovalis.	Cerithium paskentaensis.
Lucina colusaensis.	Phylloceras knoxvillensis (?).
Cardiniopsis unioideis.	Belemnites sp. Fragments.

Almost directly across the strike from this place, in beds about 2,000 feet higher, the following were collected:

Aucella crassicollis, var.	Hoplites crassicollis.
Desmoceras californicum.	Hoplites dilleri.

This is the locality on McCarty Creek, one-fourth mile east of Henderson's.

The other localities between Elder Creek and Paskenta at which Knoxville fossils other than *Aucella* have been collected are all on approximately the same horizon, very near the upper limit of the Knoxville beds, and separated from each other along the strike by intervals of about 1 mile. Beginning at the north, the first is 2 miles south of Lowreys, where the following species were obtained:

Aucella crassicollis.	Lytoceras batesi.
Anomia senescens.	Olcostephanus trichotomus.
Aporrhais sp., related to <i>Helicaulax</i> [?]	Crioceras latus.
bicarinata.	Belemnites impressus.
Desmoceras sp.	

A mile farther south a small limestone exposure and adjacent shales yielded:

Aucella crassicollis.	Turbo ? humerosus.
Nucula gabbi.	Turbo trilineatus.
Solemya occidentalis (?).	Olcostephanus mutabilis.
Astarte trapezoidalis.	

The next locality southward is on Wilcox's ranch and immediately east of it, where the uppermost layers of the Knoxville contained:

Aucella crassicollis.	Lytoceras batesi. ¹
Desmoceras sp.	Sagenopteris mantelli. ²
Olcostephanus mutabilis.	Pterophyllum californicum. ²

In this neighborhood the lower 200 feet of the Horsetown beds are fossiliferous, containing many species that are characteristic of the

¹This species was not collected in the same layers with the other species, but, from the locality given, must have come from a somewhat lower bed.

²These two species of plants were directly associated with *Aucella*. The *Pterophyllum* is a new species, named by Professor Fontaine; see Bull. Geol. Soc. Am., Vol. V, p. 450.

Lower Horsetown on the north fork of Cottonwood Creek. The following were collected:

Pecten operculiformis.	Phylloceras onoensis. ²
Plicatula variata.	Lytoceras batesi.
Nemodon vancouverensis.	Olcostephanus traski.
Pleuromya papyracea. ¹	Olcostephanus sp.
Potamides diadema.	Crioceras percostatus.
Helicaulax [?] bicarinata.	Crioceras latus.
Lunatia avellana.	Belemnites impressus.
Actæon impressus.	

This list contains several species that also occur in the Knoxville, but the general assemblage of forms is characteristic of the Horsetown. It shows the close relationship of adjacent portions of the two faunas.

The only other locality in this area to be mentioned is a little farther south, on Shelton's ranch, 5 miles north of Paskenta. Small exposures in a hill one-fourth mile northwest of Shelton's house yielded the following Upper Knoxville species:

Pentacrinus sp.	Astarte corrugata.
Cidaris? sp. Fragments.	Dentalium californicum.
Avicula whiteavesi.	Hypsipleura gregaria.
Aucella crassicollis.	Cerithium strigosum.
Pinna sp.	Olcostephanus mutabilis.
Arca textrina (?).	Hoplites angulatus.
Arca tehamaensis.	Belemnites impressus.
Leda glabra.	Belemnites sp.

It is not necessary to mention the numerous localities within this area where *Aucella* has been found, since they occur in abundance at most of the Knoxville exposures. Notes on the range of the different species and varieties of *Aucella* will be found on pages 40-41, 44, 46.

COLUSA COUNTY, CAL.

The Cretaceous strata extending southward from Tehama County through Glenn, Colusa, Lake, and Napa counties, all belong to a single area, interrupted only by occasional eruptive masses or by a covering of more recent formations, though no detailed sections including all the divisions of the Cretaceous have been studied here. In the neighborhood of Wilbur Springs, on Sulphur Creek, Colusa County, there is a great thickness of Knoxville beds. There has been considerable local disturbance of the strata by folds and faults, and I was not able to find, during a brief examination of the area, either the base or the top of the series. On the hill immediately south of Wilbur Springs there is a bed of white limestone, a few feet in thickness, closely associated with a serpentine mass. The limestone³ is very fossiliferous,

¹ This form has been referred to *P. levigata* Whiteaves in my previous papers. Gabb's name has priority.

² See p. 74.

³ A few fossils from this locality were described by Gabb in *Paleont. of Cal.*, Vol. II, and it is mentioned, with brief notes on the geology of the region by Becker, in *Mon. U. S. Geol. Surv.* Vol. XIII, p. 367.

Rhynchonella whitneyi being the most abundant species. The list of fossils obtained here is as follows:

Rhynchonella whitneyi.	Turbo wilburensis.
Modiola major.	Turbo colusaensis.
Pecten complexicosta.	Turbo ? humerosus.
Lucina colusaensis.	

The strata in contact with the limestone are not exposed for some distance, but shales and sandstones not far away across the strike on either side contain *Aucella piochii*. The species was found in the sandstone across a ravine from the Manzanita mine and at other localities west of that place; also in the shales on Sulphur Creek, less than one-half mile east of the limestone. The general dip of the rocks on either side is away from the limestone and the associated serpentine. While it is not now possible to assign this limestone to its exact position within the Knoxville beds, there can be no reasonable doubt of its Knoxville age.

On Bear Creek, near the mouth of Sulphur Creek, about a mile east of Wilbur Springs, *Aucella piochii* is very abundant, associated with *Phylloceras knoxvillensis* (?) and *Belemnites*. Still farther east there are thick beds of coarse conglomerate.

The following species from Colusa County described by Gabb in *Palæontology of California*, vol. 2, which may possibly belong to the Knoxville fauna, have not been included in this paper:

Palætractus crassus.	Ringinella polita.
Cordiera mitræformis.	Liocium punctatum.

The locality is given as south of road from Colusa to Hot Sulphur Springs, in the first range of foothills, and it is also stated that *Atresius liratus*¹ is associated with them. This species is included in the Knoxville because it has since been found associated with characteristic fossils of that formation, but the others are omitted until something more is learned of their stratigraphic occurrence. They are suggestive of a much later age. *Cordiera mitræformis* appears to be very closely related with *Scobinella dilleri* White² from the Chico, and I have identified an abundant small form in the Upper Horsetown with *Liocium punctatum*.

LAKE AND NAPA COUNTIES, CAL.

A few miles south of Sulphur Creek, in the eastern part of Lake County, *Aucella piochii* and *A. piochii* var. *ovata* occur abundantly in a coarse conglomerate. *Phylloceras knoxvillensis* (?) and *Belemnites* sp. also occur here. The locality is in the first ridge south of Cache Creek and about 5 miles north of Palmer's ranch, which is in Morgan Valley midway between Lower Lake and Knoxville. Above (south of) this ridge there are alternations of shales, conglomerates, and crystalline rocks, followed by unaltered shales and sandstones. Whether the

¹Op. cit., p. 174.

²Bull. U. S. Geol. Surv. No. 51, p. 25, PL. IV, figs. 1-3.

crystalline rocks form dikes or are interbedded eruptives was not determined. At a locality 1 mile northwest of Palmer's, and therefore apparently several thousand feet above the fossiliferous conglomerate, with *Aucella piochii*, Mr. Jasper Palmer, jr., collected the following species in a white limestone:

Pecten complexicosta.
Astarte trapezoidalis.

| *Turbo morganensis*.
| *Atresius liratus*.

Numerous specimens of *Aucella crassicollis* were collected from concretions in the shales near by, making it reasonably certain that the horizon is near the top of the Knoxville. It is probable that this is the "Morgan Valley" locality mentioned by Gabb, from which he obtained *Pecten complexicosta* and *Modiola major*.

The geology of a small area surrounding the village of Knoxville, in northern Napa County, has been described and mapped by Dr. Becker.¹ The strata are highly disturbed, so that the details of the stratigraphy have not been thoroughly determined, though the sedimentary rocks are all referred to the Knoxville division. Both *Aucella piochii* and *A. crassicollis* occur in the neighborhood, sometimes near each other, but not associated in the same stratum. It is reasonable to infer that the two forms here have the same stratigraphic relation to each other that they are known to have in regions where the structure is more simple. Other fossils are rare, the only determinable species being *Belemnites impressus* and young specimens of *Phylloceras knoxvillensis*. Dr. White also reports² *Ammonites ramosus* (?), *Potamides diadema* (?), *Lima shastaensis* (?), *Margarita* (?), *Dentalium*, *Arca*, *Nuculana*, and *Rhynchonella*. The first of these is now referred to *Phylloceras knoxvillensis*, the second may be *Amberleya dilleri*, and the others are too imperfect for identification.

MOUNT DIABLO AND OTHER LOCALITIES SOUTHWARD.

Knoxville beds occur in the neighborhood of Mount Diablo, east of San Francisco. The area has been studied and described somewhat in detail by Mr. H. W. Turner,³ and according to his map and section the Knoxville appears only on the northern and northwestern sides of the peak, where it is in contact with metamorphic and eruptive rocks. Lithologically the beds have the usual character, consisting of dark shales interstratified with thin arenaceous and calcareous layers. They are well exposed in the canyon of Bagley Creek, where, near the contact with the eruptive area, *Aucella piochii* has been collected by several parties, including the writer. At other localities in the vicinity Mr. Turner obtained fragmentary specimens of *Belemnites*, *Inoceramus*, and a few other indeterminate forms. The thickness of the Knoxville in this area has not been well determined, on account of the difficulty in fixing its upper limits in the local section. The fossils that have

¹ Mon. U. S. Geol. Surv. No. XIII, pp. 271-290.

² Bull. U. S. Geol. Surv. No. 15, p. 20.

³ Bull. Geol. Soc. Am., Vol. II, pp. 383-402.

been found in it are all in the lower portion, and there is a thickness of several thousand feet of overlying strata, in which no fossils have yet been found. On the line of a section northward from the *Aucella* locality on Bagley Creek the next fossiliferous horizon seen was in the upper part of the Chico, where *Baculites chicoensis* and a few other characteristic Chico fossils were found, only a few hundred feet below beds of Tejon (Eocene) age. The intervening strata, which are mostly covered, I estimated to be about 5,000 feet thick.

A large part of their thickness belongs to the Chico, for the exposure south of Mount Diablo yielding *Trigonia evansana*, *Nemodon vancouverensis*, *Anchura californica*, *Baculites chicoensis*, *Acanthoceras turneri*, etc., represents a low horizon in that formation, which Mr. Turner estimates to be nearly 6,000 feet thick in this vicinity. The thickness of the Chico is well shown along the railroad northeastward from the arsenal near Benicia, a few miles north of Mount Diablo. In that section the Chico can not be less than 3,000 or 4,000 feet thick.

Whether the strata lying between the Chico and the horizon of *Aucella piochii* include representatives of all the Knoxville beds with *Aucella crassicollis*, as well as of the Horsetown beds, is one of the questions yet to be answered. If the horizons are all represented, then sedimentation was here very much less rapid during a part of the Cretaceous than it was 150 miles north, in Tehama County; while if the Horsetown and a part of the Knoxville beds are really lacking, there must have been a local uplift of the Mount Diablo region which did not involve the coast ranges farther north, where Mr. Diller has shown that there was continuous sedimentation from the Knoxville to the Chico, inclusive. It is an interesting fact in this connection that the Horsetown fauna has not been found well developed any place south of Tehama County, though it doubtless will be found in the unstudied areas immediately south of that county. The reported occurrence of *Lytoceras batesi* at Benicia and south of Mount Diablo has been cited as evidence that the Horsetown beds are probably present there, but Gabb distinctly credits these specimens to the Chico.¹ It is probable that they belong to a somewhat similar but distinct species that has recently been found in the Chico on Cow Creek, Shasta County.

The presence of the Knoxville near the shore of San Francisco Bay is attested by the occurrence of *Aucella piochii* just north of Berkeley, at a locality pointed out to me by Prof. A. C. Lawson, of the State University.

Through the kindness of Prof. James Perrin Smith, of Stanford University, I have been allowed to examine specimens of *Aucella piochii* and Belemnites from a locality 7 miles east of San Jose,² and others

¹Palaeont. Cal., Vol. II, p. 211.

²Bull. Geol. Soc. Am., Vol. V, p. 257. Professor Smith compared these forms with the Russian species *Aucella mosquensis* and *A. trigonoides*, and concluded that they are probably of Jurassic age, older than the Knoxville series. He states that those from the first-named locality are from the "metamorphic phthannite series." On comparing the fossils I could not see any reason for separating them from the Knoxville forms.

that seem to belong to *Aucella piochii* var. *ovata*, from Stevens Creek Canyon, 13 miles from Mountain View, Cal.

At the most southerly known locality of the Knoxville beds, in the Santa Lucia range, 5 miles west of Santa Margarita, San Luis Obispo County, Mr. Turner¹ and Mr. Fairbanks² have collected *Aucella piochii*, and at other localities in the same county, on Toro Creek and Pine Mountain, the latter gentleman obtained *Aucella crassicollis*, indicating that at least two Knoxville horizons are represented in that region.

RIDDLES, OREG.

This locality is in southeastern Oregon, on Cow Creek, near its junction with the south fork of Umpqua River. The Cretaceous rocks here, covering an area about 5 miles long by 3 miles wide, are in contact with metamorphic rocks on the east and with serpentine and peridotite on the west. The strata at most exposures have a steep dip and seem to form a syncline, complicated perhaps by faults or minor folds. Small faults are seen at many exposures. The rocks consist of shales and sandstones, with heavy beds of coarse conglomerate, especially near the base, and with thinner calcareous bands.

Some of the exposures in the central portion of the area, as on the banks of Cow Creek just below the bridge at Riddles and in the first low ridge east of the creek, a short distance above the town, are very fossiliferous, yielding a number of species characteristic of the Horsetown beds, with some new forms that have not been seen elsewhere.

The following, with some other undetermined species, were obtained here:

Pentaerinus sp.	Cardium (Protocardia) sp.
Rhynchonella sp.	Pleuromya papyracea (=P. lævigata).
Pecten operculiformis.	Helicaulax [?] bicarinata.
Nemodon vancouverensis (=Arca breweriana).	Lytoceras batesi.
Trigonia aequicostata.	Lytoceras sp.
Trigonia leana (?).	Olcostephanus traski.
Opis sp.	Hoplites sp.
Eriphyla sp.	Belemnites impressus.

The same bed has yielded the following species of plants, identified by Professor Fontaine, who states that they indicate the Horsetown age:

Nageiopsis latifolia.	Angiopteridium oregonense n. sp. ³
Angiopteridium nervosum.	

At the second locality mentioned above, the stratum containing this assemblage of forms is not more than 150 feet above shales containing *Aucella crassicollis*, so that it is very near the base of the Horsetown. This is precisely the position that is indicated by the fauna, which is

¹ Mon. U. S. Geol. Surv. Vol. XIII, p. 381, 1888.

² 13th Rept. Cal. State Mineralogist, p. 512, 1894.

³ Not yet described.

largely identical with that of the basal Horsetown beds, on the north fork of Cottonwood Creek and in Tehama County, Cal. On the road to the nickel mines, west of Riddles, a sandstone exposure yielded *Trigonia aquicostata*, *Eriphyla* sp., *Pleuromya papyracea*, and a few others of these Horsetown species. This exposure apparently lies between others not far away in which *Aucella crassicolis* is abundant, and if the beds are in their normal relation to each other there is here an alternation of *Aucella* beds with the Horsetown fauna such as has not been seen elsewhere. It is more probable, however, that these beds have been brought into their present position by faulting or folding, as there are sudden changes in dip and other evidences of local disturbance in the immediate neighborhood. In one of these upper *Aucella* beds on the road to the nickel mines, 2 or 3 miles west of Riddles, Mr. W. Q. Brown obtained the type of *Hoplites hyatti* in immediate association with *Aucella crassicolis*.

The lower Knoxville beds of the Riddles area contain *Aucella piochii* and its variety *ovata*. This species is found near the base of the series, where it rests (probably unconformably) on the metamorphic rocks in the hills southeast and east of Riddles; also along the railroad on the banks of Umpqua River about 2 miles north of Riddles. It also occurs on the bank of Cow Creek one-half mile below the town, where the beds containing it are probably brought up by faulting.

The Knoxville beds are also well exhibited along the south fork of Umpqua River below the mouth of Cow Creek, where a thickness of several thousand feet is exposed and many of the beds are full of *Aucella crassicolis*.

In discussing the relations of the Knoxville and Horsetown beds Mr. Becker¹ has mentioned these localities near Riddles and has published a list of fossils essentially the same as the one given above (with some changes in the nomenclature), excepting that he regards *Aucella* as an associate of the Horsetown fossils mentioned. Mr. Diller,² who has visited the locality several times, and has briefly described the structure of the area, has expressed similar views concerning the relations of the fossils, though he states that he has "never been able to obtain *Aucella* and Horsetown fossils from exactly the same exposure." After visiting the locality and studying the collections made there by Messrs. Becker, Brown, Diller, and the writer, I am confident that *Aucella* has not been found associated in the same stratum with the Horsetown fauna. I think it is safe, therefore, to interpret this section as agreeing with those in Tehama County, where the Horsetown beds rest conformably on the Knoxville and the faunas are essentially distinct, though having some species in common. When the structure of the area is worked out in detail with the aid of paleontology the anomalies in the distribution of some of the beds will doubtless be explained.

¹ Bull. Geol. Soc. Am., Vol. II, pp. 203-205.

² Ibid., p. 208; Vol. IV, p. 212.

LOCALITIES IN WASHINGTON.

The presence of Knoxville beds in Washington is inferred from the occurrence of bowlders containing *Aucella crassicollis* near Seattle and Tacoma,¹ and also from the fact that *Aucella* beds are well developed in British Columbia immediately north of Washington.

THE FAUNA OF THE KNOXVILLE BEDS.

In the description of the species, forming the principal part of this paper, 77 species and varieties of invertebrates are enumerated. They have also been named in the local lists on the preceding pages. Of these 77 species, 50 are described as new, 12 have been described in previous publications, and the remainder are simply referred to genera because the material at hand is insufficient for specific diagnoses. All but 7 of the species are Mollusca, including 33 species of Pelecypoda, 1 species of Scaphopoda, 18 species of Gastropoda, and 18 species of Cephalopoda, of which 15 are Ammonoids and 3 are Belemnites. The other 7 species include 5 Brachiopoda and 2 Echinodermata (1 Crinoid and 1 Echinoid).

The very large proportion of new species will doubtless seem remarkable, but it should be remembered that the majority of them are comparatively rare, and the great abundance of *Aucella*, usually without any associates, has doubtless discouraged careful search for fossils. In the last few years, however, the discussions concerning the age of the Knoxville beds and their importance in the geology of the Pacific Coast have attracted attention to them. Mr. Diller and other geologists working in that region have therefore made special efforts to find other fossils associated with *Aucella*. The result has been the addition of an almost entirely new fauna to the Cretaceous of the Pacific Coast, though it is evident that we know, as yet, only a fraction of the fauna that existed during the Knoxville epoch. This is shown by the fact that almost every locality for fossils discovered in the Knoxville beds yields a group of new species. Only *Aucella* is distributed throughout the horizontal and vertical extent of the series.

When studying the Knoxville fauna as a whole, either in the field or from average collections, one is impressed with the excessive preponderance of the *Aucellæ*, so far as number of individuals is concerned. In many places they are so abundant that they must have actually monopolized the sea bottom, crowding out everything else.

Considering the fauna as an assemblage of species the proportion of Brachiopoda, though there are so few, is somewhat greater than in other American Cretaceous faunas. Among the Mollusca the variety of forms of Turbinidæ is noteworthy. The proportion of Ammonoids is also quite large, and there is an unusual development of the genus *Hoplites*.

¹See J. S. Diller, *Cretaceous and Early Tertiary of Northern California and Oregon*, Bull. Geol. Soc. Am., Vol. IV, p. 217.

RELATIONSHIP WITH OTHER FAUNAS.

The local lists of fossils on preceding pages show that the later portions of the Knoxville fauna are quite closely connected with the succeeding Horsetown fauna, several species passing from the one to the other. The general assemblage of forms, however, is sufficiently different for their easy recognition.¹

The fauna of the Mariposa beds on the western slope of the Sierra Nevada in central California resembles the Knoxville more closely on account of the occurrence of *Aucellæ* in it. Dr. White² referred these *Aucellæ* and those of the Knoxville to the same species, and regarded the Mariposa and the Knoxville as contemporaneous. Further studies have shown that while the *Aucellæ* from the two formations in some varieties resemble each other quite closely, they can usually be distinguished.

The Ammonites and other fossils from the Mariposa beds, so far as they are known, are entirely distinct from those of the Knoxville. Professor Hyatt says on this point, after examining nearly all of the Knoxville Ammonites here described, that "the fauna of the entire gold belt [Mariposa] series of slates have nowhere been found to contain a species similar to those of the numerous Ammonitinae found in the Cretacic faunas of the Upper Knoxville and Shasta groups."³ He lists and describes the following species from the Mariposa beds:

Cardioceras dubium.	<i>Æcotraustes denticulata.</i>
Cardioceras beaugrandi.	<i>Belemnites pacificus.</i>
Perisphinctes virgulatiformis.	<i>Avicula</i> sp.
Perisphinctes sp.	<i>Amusium aurarium.</i>
Perisphinctes sp.	<i>Aucella erringtoni.</i>
Perisphinctes filiflex (?).	<i>Aucella elongata.</i>
Perisphinctes colfaxi.	<i>Aucella aviculæformis.</i>
Perisphinctes mühlbaehi.	<i>Aucella orbicularis.</i>
Olcostephanus lindgreni.	

The beds are referred in part to the Upper Oxfordian and correlated with the Russian zone of *Cardioceras alternans*. Prof. J. P. Smith⁴ reached essentially the same conclusion concerning the age of these beds. The Mariposa is therefore regarded as older than the Knoxville. The two faunas have never been found in the same section so that their relative stratigraphic positions could be determined, the Mariposa being confined to the Sierra Nevada and the Knoxville to the Coast ranges.

Aucella-bearing strata are reported to occur near Catorce, in the State of San Luis Potosi, Mexico, by Nikitin⁵ and by Aguilera and Ordoñez.⁶ This locality is much farther east as well as farther south

¹ The larger part of the Horsetown fauna is illustrated by Gabb in the Palæontology of California. Nearly all of the species listed in the second volume from the "Shasta group, north fork of Cottonwood Creek" belong to this fauna.

² Bull. U. S. Geol. Surv. No. 15, p. 24.

³ Bull. Geol. Soc. Am., Vol. V, p. 408.

⁴ Bull. Geol. Soc. Am., Vol. V, pp. 251-256.

⁵ Neues Jahrb. für Min. Geol. und Palæont., Bd. II, 1890, p. 273.

⁶ Datos para la Geología de Mexico, 1893.

than any other place at which *Aucella* has been found on the mainland of North America. In both papers the strata are referred to the Jurassic, and the *Aucellæ* are identified with Russian species.

During the present year Castillo and Aguilera¹ have published an important paper in which the fauna of the Mexican *Aucella*-bearing beds is described and illustrated. The strata of the Catorce region are lithologically divided into three groups, which are thus described, beginning at the base:

1. Metamorphic clay slates without fossils.
2. Alternating beds of sandstone and marly and argillaceous shales, very rich in fossils.
3. Compact gray ash-colored more or less siliceous limestones, with nodules and bands of black flint. The lower part of the group is argillaceous and has a slaty structure. Fossils rare.

Of the 65 species and varieties of invertebrates described from this series, 59, including all of the *Aucellæ*, are from the middle group, in which two divisions are recognized. The lower division of group No. 2 is especially rich in Cephalopoda, of which there are enumerated 16 species of *Perisphinctes*, 4 of *Hoplites*, 3 each of *Rhacophyllites* and *Haploceras*, 2 each of *Aptychus* and *Belemnites*, and 1 each of *Nautilus*, *Olcostephanus*, and *Aspidoceras*. In the upper part of this division *Aucella* makes its first appearance associated with *Rhynchonella lacunosa*. This form of *Aucella* is referred to *A. bronni*.

The upper division of No. 2 includes the principal *Aucella*-bearing bed, in which Messrs. Castillo and Aguilera recognize the following forms of *Aucella*:

Aucella bronni.

Aucella bronni var. *lata*.

Aucella pallasii.

Aucella pallasii var. *plicata*.

Aucella pallasii var. *tenuistriata*.

Aucella volgensis.

Aucella fischeriana.

Aucella aff. *piriformis*.

Aucella terebratuloides.

These forms are said to be all found together in a series of beds with a total thickness of 5 meters, which can not be separated into different zones. Associated with *Aucella* in this division are 1 species each of *Lytoceras*, *Placentoceras* [?], *Pulchellia*, and *Olcostephanus*.

Aucella does not pass up into the upper group (No. 3 of section), which has yielded a *Lucina*, an *Exogyra*, a *Phylloceras*, and 2 species of *Hoplites* from the calcareous and marly shales at its base. The limestones of the upper part of No. 3 have yielded but a single species, *Schloenbachia* [?] related to *S. inflata*.

As to the age of these beds, after weighing the somewhat discordant evidence of the fossils, the authors conclude that the lower division of No. 2 should be referred to the Upper Jurassic, while the upper division of the same group, with the principal bed of *Aucella*, is regarded as

¹Boletín de la Comisión Geológica de México, num. 1. Fauna de la Sierra de Catorce, San Luis Potosí, México, 1895.

Neocomian. The upper member of the series is thought to represent the upper portions of the Lower Cretaceous, viz, the Aptian and the Albian.

On comparing this Mexican fauna with that of the Knoxville beds the principal points of resemblance are found in the Aucellæ and a few of the Ammonites. The forms of Aucella, so far as can be determined from the somewhat unsatisfactory photographic figures, can all be duplicated in the Knoxville. Several of the species of Hoplites are of the same type as *Hoplites storrsi*, and one of them, described as a variety of *H. calisto*, is possibly identical with it. One of the figures of *Olcostephanus potosinus* has sculpture very much like that of *O. mutabilis*, and *Placenticerus fallax*, although referred to a different genus, seems to be related to *Phylloceras knoxvillensis*. All of these, excepting a part of the Hoplites, are from the upper division of No. 2 of the section. It is reasonable, therefore, to conclude that this portion of the Catorce section is of the same age as part of the Knoxville. The lower fauna, characterized by a large number of species of Perisphinctes, is very probably older than the Knoxville, and perhaps should be compared with the fauna of the Mariposa beds, though there is a noteworthy absence of species of *Cardioceras* and several other genera of Ammonites that are characteristic of the Mariposa.

It is a remarkable fact that the fauna of the Catorce region contains none of the characteristic forms of the Texan Lower Cretaceous, which is known to cover a large part of Mexico. Its relations seem to be entirely with the boreal and Pacific faunas, although the locality is far east of the present Pacific drainage and directly south of the Texan Cretaceous area. Lithologically the upper limestones of the Catorce section seem to resemble those of the Texan Comanche series, but so far only a single species has been found in them. Further detailed studies in this portion of Mexico will probably yield data for the more satisfactory correlation of the Lower Cretaceous of the Pacific Coast with that of the Texan region, and they will certainly throw much light on an important epoch in the history of the continent.

Dr. J. Felix¹ has described a small fauna from beds that are referred to the Neocomian in Oaxaca, southern Mexico. Among the fossils are several species of Hoplites that appear to be rather closely related to some of those in the Knoxville beds. None of the species is identical, however, and too little is known of the fauna to warrant its correlation with the Knoxville.

It has already been stated that beds of the same age as the Knoxville occur in British Columbia, both on the mainland and on Vancouver and Queen Charlotte islands. This fact is fully shown in the paleontological writings of Mr. J. F. Whiteaves,² though few of the species other than *Aucella crassicollis* and *Belemnites impressus* seem to

¹ Palæontographica, Bd. XXXVII, 1891, pp. 180-189.

² Geol. Surv. Canada, Mesozoic Fossils, Vol. I, pts. 1 and 3, 1876 and 1884; Trans. Roy. Soc. Canada, Vol. I, 1882, Sec. IV, pp. 81-86; Cont. to Canadian Palæont., Vol. I, pt. 2, 1889.

be identical with Knoxville species in California. Some of the Canadian localities for *A. crassicollis* are enumerated on page 47. While the existence of the Knoxville in British Columbia is thus established, none of the formations or divisions recognized by the Canadian geologists is strictly its equivalent, and for that reason it is not practicable to determine how many of the described species really belong to the fauna of the Aucella beds. In a previous paper¹ evidence has been given that the Queen Charlotte formation includes strata belonging to both the Horsetown and the Knoxville and possibly still older beds.

Aucellæ have been found at several places in Alaska, and have been described and figured by Eichwald,² White,³ and Fischer.⁴ More recently the United States National Museum has received Aucella and associated forms from other Alaskan localities through the United States Fish Commission steamer *Albatross*, and Mr. W. J. Fisher, of Kodiak, Alaska. Taken altogether, the collections indicate that there are several horizons in the Alaskan Aucella beds, some of which are probably older than the Knoxville, and to be compared rather with the Mariposa. For example, Aucellæ from several localities on Shelikof Strait, south of the Alaskan Peninsula, closely resemble *Aucella erringtoni* or *A. bronni*. Many of those from Herendeen Bay, associated with a large *Pecten* and *Belemnites aquilateralis* Eichwald (?), seem to be identical with the Russian Jurassic *Aucella pallasii*; while other specimens from the same bay, but apparently from a different bed, are referable to the Cretaceous species *A. crassicollis*. The latter species also occurs at Port Möller. None of the other species collected in Alaska is represented in the California Knoxville.

Other faunas with which the Knoxville should be compared are those of circumpolar distribution, characterized by an abundance of Aucella,⁵ and most thoroughly known in Russia. The Aucellæ have been monographed by Lahusen⁶ and the Ammonites have been described in various papers by Nikitin, Michalski, Pavlow, and others, so as to be available for comparison. In that region Aucella ranges from the zone of *Cardioceras alternans* up through the Lower and Upper Volgian and the Petschora beds. In the lowest zone mentioned, both the Ammonites and the Aucellæ are closely related to those in the Mariposa beds, while the Petschora forms of Aucella are either identical or very closely related with those of the Upper Knoxville, and the Ammonite faunas are also similar, so far as they are known. An upper portion of the Knoxville may be considered the taxonomic equivalent of the Petschora beds, of course without predicating contemporaneity. The work of Professors Smith and Hyatt, comparing part of the Mari-

¹ Bull. Geol. Soc. Am., Vol. V, pp. 445, 446.

² Geognost. Beobachtungen über die Halbinsel Mangischlak und die Aleutischen Inseln.

³ Bull. U. S. Geol. Surv. No. 4.

⁴ In Pinart's Voyage à la côte nordouest de l'Amérique.

⁵ For further details on the distribution of Aucella, see p. 40.

⁶ Mém. du Comité géologique, Vol. VIII, No. 1, St. Petersburg, 1888.

posa beds with the zone of *Cardioceras alternans*, has already been referred to. The Ammonites of the Lower Volgian as monographed by Michalski¹ show little relationship with those of the Knoxville, indicating, so far as the evidence goes, that the Lower Volgian is older. There would then remain only the Upper Volgian and the Petschorian as the equivalents of the whole of the Knoxville. These are only suggestions, and I do not wish to be understood as making these definite correlations in such widely separated regions on the insufficient data now available. It is hoped that the Russian paleontologists will soon describe the other Mollusca from their Aucella beds, as well as the Aucella and Cephalopoda.

The development of the Aucella beds in Russia is not comparable in thickness with that of the Knoxville. In the descriptions of the local sections the total thickness given is usually only a few meters. I have not been able to find any estimates of the maximum thickness.

THE AGE OF THE KNOXVILLE BEDS.

After the above comparisons have been made this subject brings up the much discussed and apparently still unsettled question of the age of the Russian Aucella beds. Opinions have varied, from Eichwald's that they are all Cretaceous, to that of Trautschold and others that they are all Jurassic. I believe that it is now generally accepted that the lower portion is Jurassic and the upper is Cretaceous, but it is still undecided where the line between the two should be drawn. It would be beyond the scope of this paper to review the whole discussion. I will simply quote a few sentences that show the position of some of the present workers in that field.

In 1888 Nikitin made this statement concerning the Volgian:

Up to the present time the deposits of the Upper and Lower Volgian of Russia and Poland remain isolated and can not be classified with the deposits of western Europe. I have previously stated that the greatest development of the Volgian coincides with the time of the greatest retreat of the sea in central Europe, and, on the contrary, with the time of the greatest development of the southern sea which deposited the marine Tithonian and the marine Neocomian horizons, represented in central Europe by fresh-water and littoral brackish-water deposits.²

In his study of the Ammonites of the Lower Volgian, Michalski³ concludes that the fauna is autochthonous, not at all related to those of western Europe, and remarks:

As the immediate result of the above considerations, we clearly reach the conclusion that the strata containing our Ammonites are of the same age as some of the Mesozoic strata of western Europe, which in the region near Poland are either entirely lacking (Carpathians) or form a fresh-water facies (northern Germany), that is, that our Lower Volgian beds belong to the Neocomian epoch.

¹Mém. du Comité géologique, Vol. VIII, No. 2.

²Les Vestiges de la Période Crétacée dans la Russie Centrale, Mém. du Comité géologique, Vol. V, No. 2, p. 191.

³Die Ammoniten der Unteren Wolga-Stufe, Mém. du Comité géologique, Vol. VIII, No. 2, p. 486, St. Petersburg, 1894.

Pavlow finds the Russian faunas more closely related to those of western Europe, and makes definite correlations of the different zones. In one of his latest papers¹ he says:

To my mind the Lower Volgian stage—that is, the Portland of the Boulogne series—and the zones of the Upper Volgian stage of Nikitin (first stage of Rouiller) correspond to the Purbeck, that is, the fresh-water facies of the Upper Portland, for the marine equivalent of which I proposed the name Aquilonian series.

The Petschora beds with *Olcostephanus (Polyptychites) polyptychus*, *O. (Polypt.) keyserlingi*, *O. hoplitoides*, *O. decheni*, *Belemnites subquadratus*, *Aucella volgensis*, and *A. keyserlingi* are referred to the lower Neocomian.²

It is evident, then, that even if it were possible to refer the Knoxville to definite horizons of the Russian Aucella beds its age might still be questioned. One important fact that should be borne in mind is that structurally and faunally, so far as known, the Knoxville is a unit. It is true that there is a gradual change in the fauna from the lower to the upper beds, but there is no distinct break that would justify the reference of one portion to the Jurassic and another to the Cretaceous. There are some elements of the fauna, such as *Belemnites tehamaensis*, *Hoplites storrsi*, and some of the Turbinidæ, that resemble European Upper Jurassic types. *Aucella piochii* belongs to the same general type as *A. mosquensis*, which has usually been referred to the Jurassic, and it is somewhat closely related to the Aucellæ³ of the Mariposa beds, but Professor Pavlow informs me that Aucellæ very similar to *A. mosquensis* occur in the Neocomian of Russia also. These resemblances, which will be more fully mentioned in the description of the species, are not considered of sufficient importance to counterbalance the evidence of the Cretaceous age of the entire series. Some Jurassic elements are naturally to be expected in the Lower Neocomian, and it is a well-known fact that in Europe several species of Ammonites pass up from the Jurassic to the lowest Cretaceous beds.

Professor Hyatt's opinion as to the Cretaceous affinities of the Knoxville Ammonites has been cited on a previous page. That the Upper Knoxville beds containing *Aucella crassicolis* are Neocomian is shown by the resemblance of its fauna to that of the Petschora beds, now generally admitted to be Neocomian, and by its stratigraphic and faunal relations with the immediately succeeding Horsetown beds, which have been compared with the Gault by everyone who has studied their fauna.⁴ The few fossil plants that have been obtained from the Knoxville and the Horsetown also tend to show that these two formations are

¹On the Mesozoic Formations of the Government of Riazan, p. 24, Moscow, 1894. For the translation of this from the Russian I am indebted to Mr. Robert Stein.

²Ibid., pp. 21, 22, and French résumé at the end.

³See comparisons by Professor Hyatt, Bull. Geol. Soc. Am., Vol. V, pp. 404-407.

⁴It is not probable that the limits of the divisions recognized in the California Cretaceous coincide exactly with those of the European subdivisions of the Cretaceous. It has been shown (Bull. Geol. Soc. Am., Vol. V, pp. 445, 449) that the Horsetown beds probably include the lowest Cenomanian, and at their base they may contain strata older than the Gault.

closely connected, and these plants are mostly either identical or closely related with species in the Lower Cretaceous Potomac formation of the eastern United States and in the Trinity beds at the base of the Comanche series in Texas.¹

From all these lines of evidence the conclusion is reached that the entire Knoxville series is of Neocomian age.

DESCRIPTION OF THE SPECIES.

ECHINODERMATA.

The only remains of Echinodermata yet found in the Knoxville beds are spines and small fragments of the test of a *Cidaris* from Shelton's ranch, 5 miles north of Paskenta, Cal., and joints of *Pentacrinus* columns from the same place and from Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal. These have been placed in the hands of Prof. W. B. Clark, who has in preparation a monograph of the Mesozoic Echinodermata of the United States.

MOLLUSCOIDEA.

BRACHIOPODA.

RHYNCHONELLIDÆ.

Genus *RHYNCHONELLA* Fischer.

RHYNCHONELLA SCHUCHERTI n. sp.

Pl. I, figs. 1-4.

Shell small, inflated, subtriangular in outline, with the angles rounded and the front slightly emarginated. Ventral valve very convex, with a narrow, strongly incurved beak; pedicle opening small; a shallow, obscure mesial sinus extends nearly two-thirds the length of the valve, becoming deeper and broader toward the front. Dorsal valve considerably shorter and much less capacious than the ventral, and with a much more pronounced mesial sinus, which extends from near the beak to a little beyond the middle as a narrow, shallow sulcus and then abruptly broadens and deepens, so that at the front it is almost one-fourth as wide as the valve; surface smooth, showing only delicate lines of growth and very faint, almost microscopic, radiating lines.

The two figured specimens, which are of about the average size and show the extremes of variation in form and proportion, give the following dimensions: Length, 15 mm.; breadth, 16½ mm.; convexity, 10 mm. Length, 14 mm.; breadth, 15 mm.; convexity, 11 mm.

The crura are somewhat longer than in typical *Rhynchonella*, in this respect suggesting the Triassic and Jurassic genus *Rhynchonellina*,

¹ These plants are the only means by which the Lower Cretaceous of Texas and California can be compared. So far as known, their invertebrate faunas have nothing in common.

some forms of which, such as *Rhynchonellina bilobata* Gemmellaro, also resemble this species in external features.¹ The crura are not sufficiently developed, however, to justify placing the species in that genus. The hinge line is short and arched and the shell structure is fibrous. The incurving of the beak of the ventral upon the dorsal valve obscures and partly conceals the small delthyrium, and for that reason the deltidial plates have not been seen.

The specific name is given in honor of Mr. Charles Schuchert of the United States National Museum.

Locality and position.—About 100 specimens have been collected, all from a small lens of limestone, 4 or 5 feet thick, 3 miles northwest of Paskenta, Cal., and about 3,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23017.)

RHYNCHONELLA WHITNEYI Gabb.

Pl. I, figs. 5–10.

Terebratella whitneyi Gabb, 1866, Palæont. California, Vol. II, p. 35, pl. 12, figs. 62, 62a.
Rhynchonella whitneyi Gabb, 1869, Ibid, p. 204, pl. 34, figs. 105, 105a.

Shell large, subcircular in outline, inflated, the two valves being almost equally convex; no median fold nor sinus in either valve; surface ornamented with about 40 to 50 narrow, angular plications, which are equal in breadth to the deep angular interspaces; specimens with the larger number of finer ribs have quite a different aspect from the more coarsely plicate variety.

The form of the shell changes considerably during growth. In the earlier stages it is long, slender, and not very convex, having almost the outline of a *Lingula* (fig. 5). Smaller specimens are still more slender.

The specimen represented by figs. 7 and 8 shows the typical adult form. It measures 32 mm. in height, the same in breadth, and 21 mm. in convexity. This is perhaps nearly an average in size of the specimens collected, though a few broken specimens were obtained even larger than those represented by figs. 9 and 10.

The species was at first referred to the Tertiary, but before the second publication above referred to Gabb had discovered that it occurred in a limestone included in the Aucella-bearing series.* He also pointed out its close resemblance to *R. peregrina* Von Buch, a French Neocomian species.

Locality and position.—The types of the species came from "one mile east of the Excelsior mine, Napa County," and "twenty miles east of Clear Lake, on the road from Colusa to the Hot Sulphur Springs." The latter locality is probably the same as one near Wilbur Springs, on Sulphur Creek, Colusa County, Cal., from which Dr. Becker and Mr. Turner brought back specimens several years ago, and where, in 1894,

¹See Böse, Mon. des Genus Rhynchonellina, Palæontographica, Bd. XLI, Taf. VII, figs. 30, 31.

I obtained the specimens here figured, and many others. It occurs in great abundance, associated with *Pecten complexicosta*, *Modiola major*, *Lucina colusaensis*, and a few other forms, in a thin bed of white limestone. No Aucellæ are immediately associated with it, but the shales on each side of the limestone a few hundred yards distant contain *Aucella piochii*, and from the structure of the region these strata all seem to belong to one series.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23018.)

RHYNCHONELLA sp.

An apparently undescribed species of Rhynchonella is represented by several fragmentary specimens associated with *Terebratella californica* at the locality, near Stephenson's, on Cold fork of Cottonwood Creek. It is nearly the same size as the Terebratella, but more triangular in outline and marked by about 14 strong plications.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23019.)

TEREBRATULIDÆ.

Genus TEREBRATULA Lhyd.

TEREBRATULA sp.

Pl. I, fig. 11.

Shell of medium size, subovate in outline, moderately convex; sides nearly straight for a little more than half the distance from the beak to the front and diverging at an angle of about 80°; front regularly rounded; beak broad, not very prominent.

Length, 25 mm.; breadth, 24 mm.; convexity of ventral valve, about 5 mm.

The single imperfect ventral valve of this species is all that has yet been found, and it is not worth while to give it a specific name until it can be more fully characterized, though it seems not to be referable to any described American species. Its general form and the punctate character of the test make its generic reference reasonably certain.

Locality.—Near Stephenson's, on Cold fork of Cottonwood Creek, with the following species.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23020.)

TEREBRATELLIDÆ.

Genus TEREBRATELLA d'Orbigny.

TEREBRATELLA CALIFORNICA n. sp.

Pl. I, figs. 12 and 13.

Shell of medium size, suboval in outline, broader than long; cardinal margin sloping gently from the beak, joining the rounded sides by an abrupt curve; front broadly emarginate; ventral valve slightly

more convex than the dorsal, marked by about 28 strong plications, 8 of which are borne on the broad, flat mesial fold; beak moderately prominent, truncated by the large round foramen, beneath which the deltidial plates seem to be well developed; cardinal area broad and elevated.

Dorsal valve nearly flat, with a broad mesial sinus, corresponding to the fold in the ventral valve, extending from about the middle to the front; plications equal in number and similar in arrangement to those on the ventral valve.

The specimens selected for illustration are the largest in the collection. The ventral valve measures 16 mm. in length and 20 mm. in breadth, while the corresponding measurements of the dorsal valve of another individual are 14 mm. and 20 mm., respectively.

None of the valves are united, but they are associated in such a way that there can be no doubt that they belong to the same species, which is represented by 20 more or less imperfect (mostly dorsal) valves. The form of the brachidium is unknown, and the reference of the species to *Terebratella* is therefore only provisional. The shell is punctate.

Locality and position.—Near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal., in the upper part of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23021.)

MOLLUSCA.

PELECYPODA.

OSTREIDÆ.

Genus OSTREA Linnaeus.

OSTREA sp.

Pl. II, fig. 1.

Cf. *Ostrea skidegatensis* Whiteaves, 1884, Mesozoic Fossils, Vol. I, p. 243, pl. 32, fig. 1, and fig. 12 in text.

Shell of rather small size, irregularly ovate in outline, smooth. Known only from lower valves, which are quite abundant, but usually not well preserved, in the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek. As the material at hand does not show any distinctive features by which this form may be distinguished from a number of other so-called species ranging from the Cretaceous to the present time, it does not seem advisable to give it a new specific name.

Some of the specimens are about twice as large as the one figured.
(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23022.)

ANOMIIDÆ.

Genus ANOMIA Linnæus.

ANOMIA SENESCENS n. sp.

Pl. II, fig. 2.

Shell rather large, subcircular in outline, slightly oblique, depressed convex; hinge line straight, nearly as long as the shell; beak inconspicuous, not projecting beyond the hinge line and situated near the middle of it; surface marked by faint concentric undulations.

Length, 25 mm.; height, 23 mm.

Only one valve of this shell has been collected, and it does not show the characteristic muscular scars of *Anomia*, though from its form there is little doubt that it belongs to that genus.

Locality and position.—Two miles north of Lowerys, Tehama County, Cal., from the upper layers of the Knoxville beds, where it is associated with *Aucella crassicollis*, *Lytoceras batesi*, etc. The specimen was inside of a fragment of the last-named species.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23023.)

SPONDYLIDÆ.

Genus SPONDYLUS Linnæus.

SPONDYLUS FRAGILIS n. sp.

Pl. II, fig. 3.

Shell of small or medium size, almost equilateral, irregularly ovate in outline; left valve convex, with rounded, not very prominent beak and rather large, well-defined, subequal ears; surface marked by numerous small, irregularly undulating, radiating lines that show a tendency to become subspinous on well-preserved examples. Right valve unknown.

The small specimen figured is 18 mm. long and 17 mm. wide. Fragmentary specimens in the collection represent individuals having fully twice these dimensions, and some of them show the characteristic hinge structure of *Spondylus*.

Locality and position.—The 12 specimens studied all came from the fossiliferous shales in the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23024.)

LIMIDÆ.

Genus LIMA Bruguière.

LIMA MULTILINEATA n. sp.

Pl. II, figs. 4 and 5.

Cf. *Lima microtis* Gabb, 1864, Palæont. Cal., Vol. I, p. 202, pl. 26, fig. 189.

Shell large, very obliquely elongate oval, moderately convex; hinge line short; posterior ear well developed, triangular; anterior ear small and almost concealed by the inflection of the anterior side of the shell; posterior margin and base forming a regular curve from the posterior ear to near the anterior end of the shell; anterior margin abruptly inflected, so that it is nearly straight or slightly concave from the beak for three-fourths the length of the shell, and thence regularly rounded into the base; surface marked by very numerous (about 75) slender, somewhat flattened, simple, radiating ribs, which are usually slightly broader than the interspaces, excepting toward the free margins of large shells, where they become more widely separated. The irregularly undulating character of the ribs is well shown in the drawing.

Length of the largest type, 68 mm.; height, about 50 mm.

Lima microtis Gabb, from the "Chico group of Cottonwood Creek," is closely related to this species in form and general character of ornamentation. It seems, however, to be somewhat less oblique, and the interspaces between the ribs are "serrated on the sides and marked in the middle by a series of small pits or punctations," while in *L. multilineata* the interspaces are nearly or quite smooth. I have not been able to make direct comparisons with Gabb's type, but I have examined it since this collection has been in my hands, and I believe it to be distinct.

Locality and position.—Near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal., with the preceding species.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23025.)

PECTINIDÆ.

Genus PECTEN Müller.

PECTEN CALIFORNICUS Gabb ?

Pl. II, fig. 10.

Pecten californicus, Gabb, 1864, Palæont. Cal., Vol. I, p. 201, pl. 31, fig. 270.

Shell small, subovate, slightly convex; anterior ear of right valve much produced, rather slender, with a deep byssal notch below it; posterior ear small, not very distinctly marked; beak small and pointed; surface smooth or with faint lines of growth, excepting on the anterior ear, where there are several radiating lines.

Length, 8 mm.; height, 9 mm.; length of hinge line, 5 mm.

The above description is drawn from a single right valve, which agrees too closely with the description and figure of *P. californica* to warrant its separation.

Locality and position.—The specimen here described was collected in the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal. The type of the species came from the "Chico or Shasta group, Cottonwood Creek, Shasta County."

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23026.)

PECTEN sp.

Pl. II, fig. 6.

Shell rather small, subcircular in outline, depressed; surface apparently smooth; full form of the ears unknown.

Length, 21 mm.; height from beak to base, 18 mm.

A single cast of a left valve that probably belongs to an undescribed species, but not sufficient to furnish the basis for a specific name and description. It is apparently related to *P. operculiformis* Gabb and *Amusium lenticulare* Whiteaves, from both of which it differs in having a more nearly circular form and much greater length in proportion to its height.

Locality and position.—On the south fork of Elder Creek, Tehama County, Cal., about 3,000 feet below the top of the Knoxville beds, where it is associated with *Aucella piochii*.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23027.)

PECTEN COMPLEXICOSTA Gabb.

Pl. II, figs. 7-9.

Pecten complexicosta Gabb, 1869, Palaeont. Cal., Vol. II, p. 199, pl. 33, figs. 97, 97a.

Original description.—"Shell moderate in size, thin, equivalve, nearly equilateral; sides and base forming a regular curve, slightly elongated; the right side of the upper valve, and corresponding side of the lower, a little the most convex above; upper valve with the left ear a little concave on its lateral margin; shape of the right ear unknown; right ear of lower valve narrow, produced, and deeply emarginate; surface marked by about 12 or 14 radiating ribs, with sometimes an equal number of smaller ones intercalated; these are more strongly marked on the cast than externally; besides the ribs, the entire surface is closely sculptured by minute radiating lines, very variable in size."

This description was based on fragmentary specimens from "white limestone of the Shasta group, in Morgan Valley, south of Clear Lake," Lake County, Cal., and Gabb's figure is a restoration from these specimens.

The species is abundant, associated with *Rhynchonella whitneyi* and *Modiola major*, in the white limestone at Wilbur Springs, on Sulphur

Creek, Colusa County, Cal. The ears are large and triangular, and the byssal notch of the right valve is broad and comparatively shallow. The left valve is perceptibly more convex than the right. None of the specimens from this locality shows the minute radiating lines mentioned in the description; nor are they shown in the original restored figure, excepting in a magnified view of a portion of the surface. Fragmentary specimens recently collected by Mr. Jasper Palmer, jr., of Reiff, Cal., at or very near the original locality, have this fine radiating sculpture well developed. Possibly the specimens from Wilbur Springs should be separated as a variety, but they agree so closely in all other respects that it seems probable that the absence of the fine lines is due to the state of preservation. They are all more or less in the form of internal casts, none preserving the outer surface of the shell. An average specimen measures 50 mm. in height, 44 mm. in greatest length, 17 mm. on the hinge line, and 14 mm. in convexity of both valves united.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23028 and 23102.)

AVICULIDÆ.

Genus AVICULA Bruguière.

AVICULA (OXYTOMA) WHITEAVESI n. sp.

Pl. IV, fig. 1.

Cf. *Oxytoma mucronata* (M. and H.) Whiteaves, 1884, *Mesozoic Fossils*, Vol. I, pp. 238, 251; pl. 31, fig. 9; pl. 33, figs. 6, 6b.

Shell rather small, obliquely ovate; left valve convex, with greatest convexity a short distance below the beak; anterior wing small, triangular; posterior wing elongated and narrow; hinge line nearly or quite equal to the greatest length of the shell; beak prominent, projecting beyond the hinge line; anterior and basal margins forming a regular curve; posterior margin more sharply rounded; surface ornamented by about 18 rounded linear costæ, 2 or 3 of which are on the posterior wing. Some of the interspaces bear a single finer line, which does not extend to the umbo.

Greatest length, 18 mm.; height, 16 mm.; convexity of left valve, nearly 5 mm.

This description is drawn from a single specimen found with *Aucella crassicollis*, etc., in the upper part of the Knoxville beds on Shelton's ranch, 5 miles north of Paskenta, Cal. Another left valve referred to the same species, differing from the type in being slightly higher in proportion to its length, comes from the lower part of the Horsetown beds at Ono, Shasta County. Associated with the Ono specimen there are a number of right valves that probably belong to this species.

They have about the same outline, but are much less convex; the posterior wing seems to be more narrow, and the radiating lines are so small as to be inconspicuous except under a lens.

I think it probable that these fossils are identical with the form above mentioned from the Queen Charlotte Islands that has been referred to the Jurassic *Avicula* (*Oxytoma*) *mucronata* M. and H. Direct comparison of the California specimens with Meek and Hayden's original type, which was described and figured¹ under the name *Pteria munsteri* (Bronn), shows recognizable differences in both outline and sculpture. When this Jurassic form was described the name *Pteria mucronata* was suggested for it in case it should prove to be distinct, but before this work appeared Gabb had used *Avicula mucronata* for a California Triassic species;² consequently the name *mucronata* can not be applied to either of those species, and I name the Cretaceous form in honor of Mr. Whiteaves. A new name will also be given to the Jurassic species in another publication.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23029.)

Genus AUCELLA Keyserling.

Some of the specimens of *Aucella crassicollis* are in an excellent state of preservation and show well the hinge structure and other generic characters (Pl. V, figs. 1-3 and 7). The hinge plate is rather narrow, long, and toothless, but at its anterior end in the right valve there is a projecting tooth-like angle on the margin of the shell that fits into a corresponding notch under the beak of the left valve.

The ligament, which is usually described as external, was situated in a long, shallow, oblique groove, and must have been almost concealed by the overhanging edges of the valves. The most distinctive feature of the genus is the deep byssal notch and groove in the right valve, which is formed by the abrupt inflection of the shell, and is seen on internal casts almost as distinctly as on the shell itself. This narrow groove extends in a curve from the margin of the shell almost to the point of the beak, showing that it is developed at an early stage in the shell's growth. The small triangular area thus separated from the body of the shell may be regarded as the anterior ear or wing. At its anterior angle it bears the tooth-like projection above mentioned, and its free margins are both concave, the upper one fitting against the incurved beak of the left valve and the lower receiving a rounded projection on the margin of the same valve. This projecting portion of the margin, which probably represents a deflected ear, is bounded by an ill-defined groove corresponding in position to the byssal sinus of the other valve. The interlocking of these portions of the anterior margins of the two valves would seem to have served all the purposes of hinge teeth.

¹ Paleontology Upper Missouri, p. 80, Figs. A and B, in text.

² Paleont. Cal., Vol. I, p. 30; pl. 5, fig. 27.

Most authors have placed *Aucella* in the same subfamily with *Inoceramus*, though the two genera have little in common except in some cases a similarity of outline and sculpture. The presence of the byssal sinus and the simple form of the ligamental groove as compared with the row of pits for the ligament in *Inoceramus* show that they are not very closely related. The genus *Pseudomonotis* (= *Eumicrotis* Meek) is a near relative of *Aucella*, as Meek¹ long since pointed out, and no one would think of associating it very closely with *Inoceramus*.

STRATIGRAPHIC AND GEOGRAPHIC RANGE OF AUCELLA.

Lahusen's excellent monograph, "Ueber die Russischen Aucellen,"² shows that in Russia the genus begins with *A. radiata* in the lower part of the Upper Jura (Oxfordian), associated with *Cardioceras cordatum*, but first becomes abundant in the overlying beds with *Cardioceras alternans*. Thence it continues abundant, with gradually changing forms, up into the Lower Cretaceous. The earliest species (*radiata bronni*, and *pallasi*) are elongate, compressed forms, with relatively long hinge lines, distinct posterior wings on both valves, and generally with radiating striae. These are succeeded by a series of changing forms, until in the Lower Cretaceous the genus is represented by more robust, ventricose, and almost equivalve species without distinct posterior wings or radiating striae. The oldest American forms of *Aucellæ* now known, those of the Mariposa slates, closely resemble the Russian species from the zone of *Cardioceras alternans*, and it has been recently shown by Profs. J. P. Smith³ and A. Hyatt⁴ that they are associated with a similar cephalopod fauna:

In the Knoxville beds, which seem to represent all of the Neocomian, occurs the series of forms described beyond, in which nearly all the later Russian *Aucellæ* are duplicated, or are represented by similar forms, and the different types are introduced in the same relative order in both countries. It is therefore possible to determine to some extent the relative stratigraphic position of different portions of the *Aucella*-bearing series in any region by means of the forms of *Aucella* that they contain, but this does not necessarily imply that the identical or similar forms were strictly contemporaneous in such distant regions as Russia and California.

There seems to be no clear evidence of any earlier species of *Aucella* than *A. radiata*. Professor Hyatt cites⁵ *Aucella leguminosa* Stoliczka as coming from the "Tagling limestone, Lower Lias of India," in support of his view that the genus originated in the south and migrated northward, but this species really comes from the Spiti shales overlying the Tagling limestone, though it is figured on the same plate with

¹ Paleontology of the Upper Missouri, p. 53. Washington, 1864.

² Mém. du Comité géologique, Vol. VIII, No. 1, St. Petersburg, 1838.

³ Bull. Geol. Soc. Am., Vol. V, pp. 250-258.

⁴ Ibid., pp. 402-438.

⁵ Bull. Geol. Soc. Am., Vol. V, 1894, p. 407.

species from the latter horizon. Stoliczka referred the Spiti shales to the Oolite, and placed the overlying Giumal sandstone in the Upper Jura. The last-named formation has since been classed as Neocomian,¹ and it is quite probable that the Spiti shales also, which have yielded very few fossils, are younger than Stoliczka supposed. Another species, *Aucella parva* Stoliczka, has been described as from the Upper Cretaceous (Cenomanian) of India. This small form has been inadequately illustrated and needs further study. In Russia the latest Aucella beds are referred to the Neocomian, which may be taken as the general upper limit of the range of Aucella. Whiteaves has correlated the Aucella beds of British Columbia with the Gault, but judging from the stratigraphic relations of similar faunas in California and Oregon, this correlation was caused by the failure of the geologists to differentiate the horizons in the field, and fossils that really overlie the Aucella are treated as part of the same fauna.

In its geographic distribution Aucella is essentially circumpolar, though in some regions it extends far southward. It is found over a large part of Russia, in Siberia, Nova Zembla, Spitzbergen, on the Island of Andce on the coast of Norway, Kuhn Island on the east coast of Greenland, in Alaska, British Columbia, including Queen Charlotte and Vancouver islands, and the west coast of the United States as far south as San Luis Obispo County, Cal. (about latitude 35°). In Mexico it is reported from Catorce, San Luis Potosi, which is only a few miles north of the tropic, in longitude 101° west. Its occurrence in India (northern Himalayas) has already been mentioned. In all these regions it is abundant, filling the beds where it occurs, and in most of them the early types, resembling *A. radiata* and *A. bronni*, as well as the later ones, are found. Wherever the original center of distribution may have been, therefore, it seems quite certain that the genus must have been widely distributed in the Arctic and Pacific oceans considerably before the close of the Jurassic and before there was much specific differentiation. To my mind it is not unreasonable to suppose that this original stock, after being so widely distributed, may have developed in the same general direction and produced closely similar series of forms independently in different regions.

Outside of these regions of its abundant occurrence Aucella has been occasionally reported, as in England² and Austria-Hungary.³ Two species have been described from the southern hemisphere, *Aucella plicata* Zittel,⁴ from New Zealand, and *Aucella braziliensis* White,⁵ but in neither of these cases is the generic determination entirely certain.

¹ R. D. Oldham, *Geology of India*, p. 229, 2d ed., 1893.

² Pavlow, *Jurassique supérieur et crétacé inférieur de la Russie et de l'Angleterre*, Bull. Soc. Nat. de Moscou, 1889, No. 1, p. 126, pl. 3, figs. 4, 5.

³ Neumayr, *Die Fauna der Schichten mit Aspidoceras acanthicum*, k. k. Geol. Reichsanstalt, Bd. V. p. 206, Wien, 1873.

⁴ *Reise der österreichischen Fregatte Novarra*, Geol. Theil., Vol. I, pt. 2, Paläont., p. 32, pl. 8, figs. 4a, 4b, 4c.

⁵ *Contributions to the Paleontology of Brazil*, p. 56, pl. 3, figs. 11-13, in *Archivos do Museu Nacional do Rio de Janeiro*, Vol. VII.

AUCELLA PIOCHII Gabb.

Pl. IV, figs. 2-14.

- Inoceramus piochii* Gabb, 1864 (in part), *Palæont. California*, Vol. I, p. 187, pl. 25, fig. 173, *not* fig. 174.
- Aucella piochii* Gabb, 1869 (in part), *Palæont. California*, Vol. II, p. 194, *not* the figures on pl. 32.
- ? *Aucella piochii* (Gabb) Whiteaves, 1882 (in part as synonym of *A. mosquensis*), *Trans. Roy. Soc. Canada*, Vol. I, sec. 4, p. 84.
- Aucella mosquensis* [von Buch] White, 1885, *Bull. U. S. Geol. Surv.*, No. 15, p. 23.
- ? *Aucella piochii* (Gabb) Whiteaves, 1887 (in part), *Rept. Geol. and Nat. Hist. Surv. Canada*, n. s. Vol. II, p. 111b.
- ? *Aucella mosquensis* var. *concentrica* Whiteaves, 1889 (in part), *Cont. to Can. Palæont.*, Vol. I, p. 151.
- Aucella concentrica* [Fischer] White, 1889 (in part), *Mon. U. S. Geol. Surv.*, No. XIII, p. 231, pl. 4, figs. 1, 18-20.
- Aucella piochii* (Gabb) Stanton, 1894, *Bull. Geol. Soc. Am.*, Vol. V, p. 447.
- Cf. *Aucella pallasi* (Keyserling) Castillo and Aguilera, 1895, *Boletín de la Comisión Geológica de México*, No. 1: Fauna fósil de la Sierra de Catorce, p. 4, pl. 2, figs. 14, 15; pl. 3, figs. 1, 2, and 6.
- Cf. *Aucella fischeriana* (d'Orbigny) C. and A., *idem.*, pl. 3, figs. 3-5, 7-12.

The original description, omitting the references to the "left" valve, which Mr. Gabb afterwards recognized as belonging to an entirely different form—*Mytilus quadratus*—and changing "right" valve to left valve, is as follows:

"Shell small, thin, inequivalve, high, and narrow. Left valve with the beaks large, prominent, incurved, and placed directly along the anterior margin; posterior margin to the most prominent part of the base forms a pretty regular elliptic curve; anterior margin sinuated. * * * Surface marked by small concentric ribs, which sometimes take the form of moderately large undulations."

In the second volume of *Palæontology of California* the description was enlarged and modified so as to make the species include the robust, inflated forms (*A. crassicollis*) of the upper part of the Knoxville, and the typical form first described was treated as the young stage of growth. Since that time it has been customary to regard all the Cretaceous *Aucellæ* of the Pacific Coast as only varieties of one species, though sometimes they have been ranged under two names for convenience. Recent field work,¹ however, has shown that some of these forms are characteristic of particular zones in the Lower Cretaceous, and are therefore of sufficient stratigraphic importance to be treated as distinct species, even though they may be closely connected in a genetic series.

The typical variety of *A. piochii* (Pl. IV, figs. 2-4, 8, 10) may be distinguished from all the other Knoxville forms by its slender, obliquely ovate form, with very prominent, narrow umbonal region and strongly

¹ Hyatt, Trias and Jura in the Western States, *Bull. Geol. Soc. Am.*, Vol. V, p. 404. Diller and Stanton, The Shasta-Chico Series, *idem.* p. 447.

incurved beak in the left valve; by the presence of small, but well-defined posterior wings or ears on both valves, making the hinge line straight; and by somewhat regular, small, concentric undulations. The right valve is much less convex, with a more elliptical outline, the beak scarcely projecting beyond the hinge. The anterior ear of this valve is very small and is separated from the body of the shell by the narrow byssal sinus.

Occasional specimens are found showing faint radiating striae (fig. 9), and such examples very closely resemble *Aucella erringtoni* var. *arcuata* Hyatt from the Jurassic Mariposa slates, which has almost the same form. The resemblance is so close that they probably would not be separated if they were found together or with the same faunal associates. As Professor Hyatt has pointed out, the facts at present known seem to indicate that *A. piochii* is the direct descendant of *A. erringtoni*.

Of the Russian forms figured by Lahusen, *Aucella mosquensis*, *A. fischeriana*, and *A. trigonoides* may be compared with *A. piochii*, but none of the specimens or figures of these species I have seen shows such a prominent incurved beak nor so narrow an umbonal region suddenly expanding into the body of the shell below as in the left valve of *A. piochii*.

*Variety ovata*¹ (Pl. IV, figs. 11-14).—This variety, which occurs with the preceding, though it ranges a little higher in the Knoxville beds, may be distinguished from it by its larger size, more broadly triangular form, greater convexity, and coarser, more remote concentric undulations. The posterior ear is scarcely at all developed in either valve, and the beak of the right valve is much more prominent and pointed, so that the hinge line is short and angular.

This form resembles the Russian *A. mosquensis* var. *ovata* and *A. trigonoides*, which, according to Lahusen, seem to be connected with each other and with *A. keyserlingi* by transition forms. In the upper part of the Knoxville beds there are occasional specimens that I at first referred to this variety (Bull. Geol. Soc. Am., Vol. V, p. 448), but which now seem to me rather a variety of *A. crassicollis*, and they are very much like the figures of *A. keyserlingi* (see Pl. V, figs. 12, 13).

The small specimen represented by Pl. IV, figs. 6 and 7, is intermediate between the typical *A. piochii* and var. *ovata*, as it has the slender form of the one and the sculpture, convexity, and pointed right valve of the other. The very large specimen (Pl. IV, fig. 14) is another extreme variation, approaching *A. crassicollis* var. *gracilis* in outline and size, but the character of the umbonal region shows its relationship to *A. piochii* var. *ovata*.

In size *A. piochii* is usually small, the greatest length, measured obliquely from the beak, seldom exceeding 30 or 35 mm., and the greatest breadth at right angles to that line is about 20 mm.

¹ Bull. Geol. Soc. Am., Vol. V, p. 447.

One distinctive character, as compared with *A. crassicollis*, is the extreme thinness of the shell, even in the larger varieties.

Locality and position.—The typical form occurs alone in the lowest known fossiliferous beds of the Knoxville. It ranges through several thousand feet of strata, and in the upper part of its range is associated with the variety *ovata*. The latter is the predominant form at a horizon about 2,000 feet below the top of the Knoxville, and above this horizon of its culmination it is gradually replaced by *Aucella crassicollis*. The original figures on Pl. IV are all from specimens collected on the south fork of Elder Creek, Tehama County, Cal., and between that and the north fork of the same creek, excepting fig. 4, which was collected $2\frac{3}{4}$ miles northwest of Paskenta. The striated specimen (fig. 9) is from the neighborhood of Knoxville, Napa County, Cal.

The species is also known from the Santa Lucia Range, in San Luis Obispo County, 5 miles west of Santa Margarita, where it has been collected by Mr. Turner¹ and by Mr. Fairbanks;² from the mouth of Alum Rock Canyon, 7 miles east of San Jose, where it was obtained by Prof. J. P. Smith,³ who mentioned it as *Aucella* of the type of *A. mosquensis*; from the north side of Mount Diablo, the neighborhood of Berkeley, and many places farther north in the coast ranges of California; from the neighborhood of Riddles, Oreg., and near Seattle, Wash.

Judging from the published figures, it is probable that some of the *Aucellæ* collected near Catorce, in San Luis Potosi, Mexico, belong to this species, and especially to the variety *ovata*, though they have all been referred to Russian species.

The *Aucellæ* collected by Dr. George M. Dawson on the Skagit River, British Columbia, in 1875, seem to belong to *Aucella piochii* var. *ovata*. Those from other British American localities that I have been enabled to examine, through the kindness of Mr. J. F. Whiteaves, are all *Aucella crassicollis*, under which name the localities will be enumerated. Judging from the range of these forms in California, only the upper part of the *Aucella*-bearing beds have yet been found in British Columbia. The specimen from Queen Charlotte Islands, referred to *Aucella mosquensis* and figured in *Mesozoic Fossils*, Vol. I, pl. 10, figs. 3, 3a, is most probably not an *Aucella*; indeed, it seems to me more nearly related to the *Astartidæ*.

(National Museum Catalogue, *Mesozoic Invertebrate Fossils*, 23030-23033.)

¹ Mon. XIII, U. S. Geol. Surv., p. 381.

² Twelfth Rept. State Mineralogist of California, p. 512, San Francisco, 1894.

³ Bull. Geol. Soc. Am., Vol. V, p. 257.

AUCELLA CRASSICOLLIS Keyserling.

Pl. V, figs. 1-13; Pl. VI, figs. 1-5.

Aucella crassicollis Keyserling, 1846, Reise in das Petschora-Land, p. 300, pl. 16, figs. 9-12.

Aucella piochii Gabb, 1869 (in part), Palaeont. California, Vol. II, p. 194, pl. 32, figs. 92a-92c.

Aucella piochii (Gabb) Whiteaves, 1882 (in part), Trans. Roy. Soc. Canada, Vol. I, sec. 4, p. 84; 1884, Mesozoic Fossils, Vol. I, p. 239; 1887 (in part), Geol. and Nat. Hist. Surv. Canada, Vol. II, n. s., p. 111b.

Aucella concentrica (Keyserling) Toula, 1874, Zweite deutsche Nordpolarfahrt, Vol. II, p. 503, pl. 2, figs. 2-4.

Aucella concentrica (Fischer) White, 1884, Bull. U. S. Geol. Surv. No. 4, p. 13, pl. 6, figs. 2-12; 1885, Bull. U. S. Geol. Surv. No. 15, p. 23; 1889 (in part), Mon. U. S. Geol. Surv. No. XIII, p. 231, pl. 4, figs. 3-5, 11-17, and 21.

Aucella crassicollis and var. *gracilis* Lahusen, 1888, Ueber Russischen Aucellen, pp. 21, 42, pl. 5, figs. 8-16, where European synonymy is given.

Aucella piriformis Lahusen, 1888, *ibid.*, pp. 22, 42, pl. 5, figs. 1-7.

Cf. *Aucella terebratuloides*, *inflata*, and *keyserlingi* Lahusen, *ibid.*, pp. 18-22, 29-41, pl. 4, figs. 1-21.

Cf. *Aucella bulloides* Lahusen, *ibid.*, pp. 25, 43, pl. 5, figs. 17-19.

Aucella crassicollis (Keyserling) Stanton, 1894, Bull. Geol. Soc. Am., Vol. V, p. 448.

Cf. *Aucella terebratuloides* (Trautschold) Castillo and Aguilera, 1895, Boletín de la Comisión Geológica de México, No. 1, Fauna fósil de la Sierra de Catorce, p. 4, pl. 3, fig. 13.

Cf. *Aucella volgensis* (Lahusen) C. and A., *idem.*, pl. 3, figs. 14-16.

Shell attaining a large size, ovate in outline, but varying greatly in the relation of length to breadth, ventricose, with the two valves almost equally convex; beaks approximate, in left valve prominent and more or less strongly incurved, in right valve pointed and deflected forward; surface variable, some specimens being almost smooth, with irregular concentric furrows and constrictions, while others are marked by strong concentric plications both on the surface of the shell and on the casts; posterior wing not developed on either valve; byssal groove and notch deep and conspicuous. The right valve is always shorter and more triangular than the left.

This description is meant to include all the robust varieties of *Aucella* that are characteristic of the upper part of the Knoxville beds in California, ranging through perhaps 1,500 or 2,000 feet of strata. The figures given illustrate the principal variations in form, but the individual variation is so great that one seldom finds two specimens exactly alike.

A precisely similar series of forms has been described from the Lower Cretaceous of Russia and beautifully illustrated by Lahusen. The name *A. crassicollis* was originally given to an elongate form (*A. crassicollis* var. *gracilis* Lahusen) with irregular concentric constrictions, much like the one represented by figs. 10 and 11 on Pl. V. The type differs from the California specimen principally in having the beaks more distinctly coiled and incurved, but this distinction will not hold,

for we have other California specimens from the same bed and locality that show this feature, and there are others that show the intermediate amounts of incurving.

Lahusen has recognized the shorter, more ventricose, forms, like our figures 3, 4, and 9 of Pl. V, as varieties of *crassicollis*, but other specimens that seem to differ only in having the beak of the left valve less distinctly spiral are separated under the name *A. piriformis*, which he says "is closely connected with *A. crassicollis* by gradual transitions" and is everywhere associated with it. These facts seem to me sufficient reason for assigning all these forms to the same species.

The name *Aucella concentrica* Fischer de Waldheim, which has been used by many authors for this species, was justly rejected by Lahusen. The only reason it has ever been used is because Fischer de Waldheim¹ published three figures of *Aucella* under the name "*Inoceramus concentricus* Brongniart," and when his fossils were found to belong to a new genus as well as a new species the specific name by which he had known them was retained and credited to him. Lahusen's name, *piriformis*, was proposed for precisely the same forms with citations of Fischer's figures, but if it is really conspecific with *A. crassicollis* Keyserling, as I believe, Keyserling's name must be used under the rule of priority.

The large forms thus far referred to are especially characteristic of the uppermost Knoxville beds, and I think that no one who has handled large collections of them would hesitate to refer them to one species. Some of the others may perhaps be considered rather more doubtful, but I have failed to find any constant feature or any combination of characters by which they may be separated. Figs. 8, 12, and 13 of Pl. V, also from the Upper Knoxville, approach *A. piochii* var. *ovata* in form, but they are less oblique, and differ in surface sculpture, and there is evidence from connecting forms that they belong with *A. crassicollis*. Figs. 12 and 13 are also much like Lahusen's figures of *A. keyserlingi*.

Figs. 3, 4, and 5 on Pl. VI represent a strongly plicate variety that also ranges to the top of the Knoxville beds, though the specimens illustrated were obtained 1,500 or 2,000 feet lower, north of Paskenta and one-fourth mile east of Henderson's. Judging from Lahusen's figures, they may be considered intermediate between *A. inflata* and *A. terebratuloides*. At many localities the specimens all have these strong concentric ridges, but the sculpture is not sufficiently constant for use as a specific distinction.

The small specimen represented by figs. 5 and 6 on Pl. V is from a still lower horizon, associated with great numbers of *A. piochii* var. *ovata* and *Belemnites tehamaensis*. It differs from the common form of *A. crassicollis* in its smaller size, somewhat longer hinge line, and broader beak of the right valve.

¹ Oryctographie de Moscou, pl. 20, figs. 1-3, St. Petersburg, 1830.

A. crassicollis is by far the most abundant species of *Aucella* in the collections that have been brought in from California. It occurs at many localities in the coast ranges, from San Luis Obispo County, where it was recently collected by Mr. Fairbanks, northward to the Cold fork of Cottonwood Creek, though I do not know any localities at which it has been obtained between San Luis Obispo County and Napa and Lake counties. It occurs also at Riddles, and at other localities in Oregon and Washington.

The *Aucellæ* from the following localities in British Columbia belong to this species, viz: Queen Charlotte Islands, south shore, opposite Cowgatz; Forward Inlet, Quatsino Sound, Vancouver Island; Tatlayoco Lake, latitude $51^{\circ} 30'$, longitude $124^{\circ} 30'$, and Harrison Lake. It also occurs on Kuhn Island, east coast of Greenland; at Port Möller, Peninsula of Alaska, and at many localities in northern Russia.

The original figures on Pl. V and figs. 3-5 of Pl. VI are all from specimens collected between Elder Creek and Paskenta, Tehama County, Cal., excepting Pl. V, figs. 1 and 2, which is from near Stephenson's, on the Cold fork of Cottonwood Creek, Tehama County.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23034-23039.)

Genus INOCERAMUS Sowerby.

INOCERAMUS OVATUS n. sp.

Pl. IV, fig. 15.

Shell of medium size, elongate ovate in outline, subequivalve, moderately convex; beaks prominent, narrow, pointed, curved slightly forward, and situated near the anterior end of the very short hinge line, which is oblique to the longer axis; surface of the shell and of the cast marked by distant, obscure, irregular, concentric undulations parallel with the lines of growth.

Length of shell equal to about two-thirds of height.

This form resembles some of the varieties of *I. fragilis* H. and M., from which it may be distinguished by the shorter hinge line, fuller anterior margin, and less oblique form. None of the described species from the Pacific Coast resembles this one closely enough to require detailed comparison.

Locality and position.—On the south fork of Elder Creek, Tehama County, Cal., about 2,000 feet below the top of the Knoxville beds, where a single specimen was found associated with *Aucella piochii* var. *ovata* and *Belemnites tehamaensis*.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23040.)

MYTILIDÆ.

Genus MODIOLA Lamarek.

MODIOLA MAJOR Gabb.

Pl. III, fig. 1.

Modiola major Gabb, 1869, Palæont. California, Vol. II, p. 191, pl. 31, fig. 88.

Original description.—"Shell very large, thick, slightly curved; beaks small, about an eighth of the length from the anterior end, which is narrowly rounded and produced; cardinal margin slightly arched; base concave in the middle, convex posteriorly; posterior end irregularly convex, most prominent below; surface marked by coarse, irregular lines of growth.

"Length, 4.8 inches; width, 2.4 inches; diameter, about 1.5 inches.

"Common in the white limestone of the Shasta group, east of Knoxville, Lake County; also found smaller in the same beds in Morgan Valley, south of Clear Lake, Colusa County.

"A fine species, well characterized by its size, being the largest species of the genus with which I am acquainted. Some specimens are over 6 inches in length."

The specimen figured on Pl. III, which is the largest I have seen, is not quite so slender as Gabb's original figure, but the smaller specimens associated with it in the same bed are also more slender. It was obtained from a limestone in the lower part of the Horsetown beds, about 1 mile east of Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal. Mr. James Storrs has recently collected the species from about the same horizon on the north fork of Cottonwood, near the mouth of Eagle Creek, Shasta County. The localities mentioned by Gabb are probably all in the Knoxville beds. I found it quite abundant, associated with *Pecten complexicosta*, *Rhynchonella whitneyi*, etc., in the white limestone near Wilbur Springs, Colusa County, which is certainly in the Knoxville. This is therefore one of the species that are common to the Knoxville and Horsetown beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23041.)

Genus MYOCONCHA Sowerby.

MYOCONCHA AMERICANA n. sp.

Pl. II, fig. 11.

Shell rather small, slender, subovate, gently convex; beak small, almost terminal; dorsal margin nearly straight, passing by a gentle curve into the rounded posterior end; ventral margin also nearly straight, slightly contracted toward the front, and gently convex

behind; shell gradually broadening from the narrow anterior end for about two-thirds of its length, and thence rounded to the posterior end; surface marked by lines of growth.

Length, 41 mm.; greatest width, 22 mm.

The genus *Myoconcha* has not before been recognized in American strata, and the present species is represented by only a single right valve, but the general form and the presence of a single tooth and a long groove for the external ligament make its generic reference reasonably certain.

Locality and position.—Near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal., in the upper part of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23042.)

PINNIDÆ.

Genus PINNA Linnaeus.

PINNA sp.

Pl. II, fig. 12.

A single very small valve of a young *Pinna* was found in the upper part of the Knoxville beds, on Shelton's ranch, 5 miles north of Paskenta, Cal. As it is probable that an adult shell would not be recognizable from the figure and description of this specimen, I have not ventured to give it a name.

The right valve is elongate subtriangular in outline, increasing rapidly in breadth from the very narrow pointed front end, carinated, the carina beginning at a point about 1 millimeter behind the beak, and curving slightly downward, so that the dorsal area is somewhat broader than the ventral; posterior end of the dorsal area squarely truncate, while the corresponding margin of the ventral area is directed very obliquely forward with a slightly sinuous outline; surface marked by very distinct, sharply elevated lines parallel to the posterior margin and averaging one-half millimeter apart, crossed by much finer, closely arranged radiating lines and the narrow median carina. There is also another faintly marked ridge passing down the middle of the dorsal area.

Length of the young individual, 9 mm.; greatest breadth, 6 mm.

The extreme apex of the shell—about one-fourth of a millimeter—is slightly eroded, but the radiating lines extend as far as the original surface remains, and the beak seems to have been strictly terminal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23043.)

ARCIDÆ.

Genus ARCA Linnæus.

ARCA TEHAMAENSIS n. sp.

Pl. VI, fig. 8.

Shell small, elongate subtrapezoidal in outline; hinge line as long as the shell, with a low area; beak elevated, prominent, situated about one-third the length of the shell from the anterior end, which is rounded and slightly narrower than the posterior end; base nearly straight and almost parallel with the cardinal margin; posterior end truncate, forming an angle of about 100° with the cardinal margin; posterior umbonal ridge prominent, subangular, and the portion of the shell above it much depressed; surface marked by distinct, somewhat regular lines of growth and by much finer, more closely arranged radiating lines, which are visible only under a lens and are most prominent on the posterior portion of the shell.

Length, 7 mm.; height, 4 mm.

The specimen above described is a natural mold of a right valve, probably an immature individual. It may be identical with the undescribed *Arca* from the Lower Cretaceous of Jackass Mountain, British Columbia, mentioned by Whiteaves (Trans. Roy. Soc. Canada, Vol. I, Sec. IV, p. 85) as similar to *Arca carteroni* d'Orbigny. *Nemodon fischeri* (d'Orbigny) Whiteaves, from the east end of Maud Island, seems to be a related form, and if our specimen is a very young shell it may prove to be identical, though there are differences in the outline, especially of the base, and in the form of the posterior end. I have not seen the hinge, but the general form of the shell makes it probable that it belongs to the subgenus *Nemodon*.

Locality and position.—Shelton's ranch, 5 miles north of Paskenta, Tehama County, Cal., in the upper part of the Knoxville beds, where it is associated in the same layers with *Aucella crassicollis*, *Hypsipleura gregaria*, etc.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23044.)

ARCA TEXTRINA n. sp.

Pl. VI, figs. 6 and 7.

Shell of medium size, elongate suboval in outline, moderately convex; hinge line considerably shorter than the greatest length of the shell, with a low area; base nearly parallel with the hinge, slightly sinuous in the middle and abruptly rounded into the oblique posterior end, which joins the dorsal margin in a gentle curve; beaks broad, not prominent; a broad, obscure depression extending from the beak to the middle of the base; surface marked by distinct, closely arranged lines of growth and by similar slightly larger radiating lines, which are not at all conspicuous to the unaided eye.

Length of the largest specimen seen, 38 mm.; height, 23 mm.; convexity of single valve, about 10 mm.

In size and general form this species may be compared with the *Grammatodon inornatus* Whiteaves, not M: and H. (Mesozoic Fossils, Vol. I, pl. 31, figs. 8a, 8b), from which it may be distinguished by its shorter hinge, more rounded ends, broader umbonal region, and the presence of radiating striæ.

Locality and position.—Near Stephenson's, on the Cold fork of Cottonwood Creek, Tehama County, Cal., in the upper part of the Knoxville beds.

Several small specimens collected at the locality on Shelton's ranch have the same form as this species, and probably are young individuals of it. One of these shows an impression of the hinge with elongate, nearly horizontal teeth at each end and short transverse ones in the middle, so that it should probably be referred to the subgenus *Nemodon*.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23045.)

Genus PECTUNCULUS Lamarck.

PECTUNCULUS ? OVATUS n. sp.

Pl. VI, figs. 9 and 10.

Shell small, subovate in outline, slightly oblique, convex; beaks rather narrow and prominent; front and base regularly rounded; posterior end subtruncate; surface marked by 8 or 10 prominent radiating costæ that are not quite as wide as the interspaces and are almost as prominent on internal casts as on the shell itself. These costæ on the anterior part of the shell are sharply angular, while all the others appear to be rounded, at least on the cast.

The hinge of this species, as determined from a cast of the right valve, consists of a curved series of about 12 or 14 transverse teeth, thus apparently agreeing with the genus *Pectunculus*, though its form and sculpture differ considerably from the common species of that genus.

Locality and position.—Near Stephenson's, on the Cold fork of Cottonwood Creek, Tehama County, Cal., in the upper part of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23046.)

NUCULIDÆ.

Genus NUCULA Lamarck.

NUCULA GABBI n. sp.

Pl. VI, figs. 11 and 12.

Shell of medium size, subovate in outline, posterior end very short, obliquely truncate above, regularly rounded into the base below; dorsal margin in front of the beaks gently curved to the anterior end,

which is more narrowly rounded into the slightly convex base; beaks prominent, approximate and situated very near the posterior end of the shell; free margin smooth within; surface marked only by very fine but distinct lines of growth.

Length of the largest specimen seen, 20 mm.; height, 16 mm.; convexity of the two valves united, about 12 mm.

This species may be compared with *N. solitaria* Gabb (Palaeont. Cal., Vol. II, p. 197, pl. 32, fig. 94), a Chico species from Texas Flat, Cal., which has, however, a more distinctly triangular outline than the form here described, besides being smaller and coming from a much higher horizon. Whiteaves's figures of *N. solitaria* from Queen Charlotte Islands are rather more like the present species, and as they also come from a lower horizon they may be identical with it.

Locality and position.—The type is from the upper part of the Knoxville beds, about 3 miles south of Lowerys, Tehama County, Cal. Several much smaller specimens were collected from a lower horizon in the small limestone 3 miles northwest of Paskenta.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23047.)

NUCULA STORRSI n. sp.

Pl. VI, figs. 13 and 14.

Shell of medium size, elongate subtriangular, convex; beaks large, prominent, approximate, situated a little less than one-third of the length of the shell from the anterior end; dorsal margin excavated behind the beak and gently sloping in front; posterior end narrowly rounded, subangular above; anterior end produced, narrowed and subangular at the extremity; ventral margin forming a broad curve or nearly straight; test moderately thick, with the inner free margin smooth; surface marked by very fine, closely arranged concentric lines that are barely visible without a lens.

Length of the figured specimen, 23 mm.; height, 13 mm.; convexity of both valves united, 10 mm. One other example is 26 mm. long, but all the rest of the nine specimens collected are considerably smaller than these two.

This species in general form resembles *Leda* rather more than the typical species of *Nucula*. It agrees with *Nucula*, however, in its thick shell, the apparent absence of a pallial sinus, and the fact that the beaks are turned toward the shorter end, which is therefore regarded as the posterior end. There is no closely related American Cretaceous species with which I am acquainted.

The specific name is given in honor of Mr. James Storrs, of Tehama, Cal., by whose skill and energy as a collector a large part of the species described in this paper was discovered.

Locality and position.—From the small limestone, 3 miles northwest of Paskenta, Cal., and about 3,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23048.)

Genus LEDA Schumacher.

LEDA GLABRA n. sp.

Pl. VI, fig. 15.

Shell small, subequilateral, moderately convex; beaks small, situated very slightly in advance of the middle; cardinal border almost straight, being a little concave behind the beak and sloping very gently downward in front; anterior end narrowly rounded, but somewhat broader than the posterior end, which is subangular above; ventral margin broadly and regularly rounded; surface smooth or marked only by lines of growth.

The figured specimen, which is somewhat smaller than some of the other examples of the species, measures 9 mm. in length and 5 mm. in height.

This form has about the same outline as *Yoldia arata* Whiteaves (Mesozoic Fossils, Vol. I, p. 233, pl. 31, figs. 4 and 4a) from the Queen Charlotte Islands, but it is easily distinguished by its smoother surface. It is possible that the casts from the Aucella beds of Vancouver Island, doubtfully referred to *Y. arata* (Cont. to Canadian Paleont., Vol. I, p. 154), belong to the present species. As no other described species from the Cretaceous of the Pacific Coast is comparable with this one, I have thought it advisable to give it a provisional name, although it belongs to a persistent group that has very few salient features on which specific distinctions can be based.

Locality and position.—The type is from the fossiliferous shales in the upper part of the Knoxville beds near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County. Other examples were collected from about the same horizon on Shelton's ranch, 5 miles north of Paskenta, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23049.)

CARDINIIDÆ.

Genus CARDINIOPSIS n. gen.

Shell in the type species large, elongate suboval, with the posterior end somewhat narrowed; ligament external, prominent, and long; hinge plate rather broad and flattened, bearing in the right valve a single moderately large triangular cardinal tooth, which is situated immediately below the beak, directed slightly forward and bordered on each side by a shallow pit; hinge of the left valve with two smaller diverging cardinal teeth inclosing between them a triangular pit for the reception of the tooth of the right valve; no lateral teeth; anterior adductor muscular impression large, subcircular, deeply impressed, with a well-marked, deep accessory muscle scar situated just above and behind it and impinging on the front part of the hinge plate; posterior adductor muscular scar very slightly impressed and so obscure that its

outlines are not distinguishable on any of the casts; pallial line well marked on the front half of the shell, but fading out so that it can not be traced posteriorly, but it is probably entire. (Elongate and thin-shelled species of *Unio* have similar faint muscular impressions on the posterior portion of the shell.) Type: *Cardiniopsis unioides* n. sp., described on a succeeding page.

The habitat of the type species was marine waters, where it was associated with *Rhynchonella*, *Aucella*, *Lucina*, *Nucula*, *Solemya*, *Turbo*, *Amberleya*, *Ammonites*, *Belemnites*, etc.

The external features of the large *Unio*-like shells, for which this new generic name is proposed, suggest at once a comparison with the *Unionidæ* and with the genera of similar aspect in the Paleozoic and earlier Mesozoic, such as *Anthracosia*, *Carbonicola*, *Asthenodonta*, *Uniona*, *Cardinia*, *Trigonodus*, etc.

In the *Unionidæ* the only genus with which comparison needs to be made is *Unio* itself, from which *Cardiniopsis* may be distinguished by the absence of lateral teeth¹ and by the character of the cardinal teeth, which are smooth, regular, and sharply defined in *Cardiniopsis*, while in *Unio* they are irregular in form, roughened, and striated; also by the difference in the number and position of the anterior accessory muscular impressions; and it differs from all known *Unionidæ* in its marine habitat. The genera mentioned above as associates of *Cardiniopsis* leave no doubt as to the marine character of the bed in which they are found, and the manner of their occurrence makes it certain that the specimens of *Cardiniopsis* were not drifted in from a river or other fresh waters, but that they actually lived with the species that are now found with them. They are relatively abundant in the small area of a few square yards where they have been found, and almost all the specimens have both valves united and nearly closed. Some of them are filled with *Rhynchonella*, *Aucella*, and other small forms, and none of them shows any evidence of erosion.

Uniona,² a marine genus from the Trias, has hinge structure and muscular impressions very much as in *Unio*, and hence differs in a similar manner from *Cardiniopsis*.

In some species of *Trigonodus*, from the Trias, and *Cardinia*, from the Jura (especially Lias), the cardinal teeth have somewhat greater resemblance to those of *Cardiniopsis*, but both these genera also have long, well-developed laterals.

The Paleozoic genera *Anthracosia*, *Carbonicola*, and *Asthenodonta*,³ though having the same *Unio*-like form, differ too much from *Cardiniopsis* in their internal features to require detailed comparison.

In consideration of all the known characters of this fossil, its natural position seems to be near *Cardinia* and *Trigonodus* in the family Car-

¹ These are also absent in some species of *Unio* that have been grouped under the name *Margaritana*, which, according to Mr. Charles T. Simpson, is not a valid genus.

² Pöhlig, *Maritime Unionen*, *Palaontographica*, Bd. XXVII, pp. 109-127, pls. 13, 14, Cassell, 1880.

³ J. F. Whiteaves, *Unio-like Shells in the Coal Measures at the South Joggins, Nova Scotia*, *Trans. Roy. Soc. Canada, Sec. IV*, 1893, pp. 21-24.

diniidæ, as defined in Zittel's Handbuch der Palæontologie and in Fischer's Manuel de Conchyliologie. A recent writer,² however, thinks that the family Cardiniidæ is not a valid one, and that Cardinia and Trigonodus should be placed in the "Nayades" or "Nayadidæ," which includes the Unionidæ. If this view be adopted Cardiniopsis will go into that group.

CARDINIOPSIS UNIOIDES n. sp.

Pl. VII, fig. 5; Pl. VIII, fig. 1; Pl. IX, fig. 1; Pl. X, fig. 1.

Shell large, elongate suboval, moderately convex; beaks not very prominent, approximate, and situated about one-third of the length of the shell from the front; cardinal margin descending rather rapidly, with convex outline in front of the beak and sloping more gently, with slightly concave outline behind; front end broadly rounded; posterior end narrower and more compressed, obliquely subtruncate above and rounded below; ventral margin forming a broad curve, most convex and prominent in the anterior third; surface marked by irregular and not very prominent lines of growth; test rather thick, especially in the ventral region. The characteristics of the hinge and other internal features are given above in the generic description.

One of the type specimens measures 175 mm. (nearly 7 inches) in length, 98 mm. in height, and about 55 mm. in greatest convexity of the two valves. The largest specimen collected is 8 inches long.

This is the largest species of the Pelecypoda known from the Knoxville beds, and, excepting the Inocerami; one of the largest from the American Cretaceous.

Two fragmentary specimens of another species of this genus were collected with *C. unioides*, but they are too imperfect for full description. In size and general appearance they resemble *Lucina colusaensis*, but impressions of the hinge show that it had the same structure as in *C. unioides*.

Locality and position.—In the small limestone, 3 miles northwest of Paskenta, Tehama County, Cal., and about 3,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23050.)

SOLEMYIDÆ.

Genus SOLEMYA Lamarck.

SOLEMYA OCCIDENTALIS n. sp.

Pl. X, figs. 2 and 3.

Shell rather large, elongate oval, convex; beaks broad, but not prominent, and directed backward; posterior end very short and narrowly rounded; anterior end much produced and broader, but toward the

²S. Frh. von Wöhrmann, Ueber die systematische Stellung der Trigoniden und die Herkunft der Nayaden, Jahrb. der k. k. geol. Reichsanstalt, Bd. XLIII, pp. 1-28, Wien, 1893.

extremity sloping gradually, both above and below, and finally somewhat narrowly rounded; ventral margin broadly emarginate just behind the middle, then curving outward so that the shell's greatest height is about one-third of the length from the front, thence curving upward more rapidly toward the end of the shell; surface marked by distant radiating impressed lines, which are most prominent on the middle portion, and by obscure elevated radiating ridges, which are most distinct on the anterior half of the shell. In addition to these lines and ridges, which are as distinct on the internal cast as on the surface of the shell, some well-preserved casts show numerous very fine and closely arranged radiating lines that are visible only under a lens. The test is rather thin, and so fragile in its crystalline condition that in most cases it was entirely removed in breaking out the specimens.

Length of a specimen a little above the average size, 58 mm.; height at the beaks, 20 mm.; height near the anterior end, 23 mm.

The most salient features of the sculpture in this group seem to be generic characters, or at least they are repeated in many species. The present species may be readily distinguished from the three forms that have been described from the American Upper Cretaceous by its larger size and by differences in outline. It may be compared with *Solenomya costata* Tullberg (Bihang till K. Svenska Vet.-Akad. Handlingar, Bd. VI, No. 3, 1880, p. 11, pl. 1, figs. 15, 16), which occurs in the Aucella beds of Nova Zembla. Another related species of about the same size, but with different outline, is *S. torelli* Lindström (K. Svenska Vet.-Akad. Handlingar, Bd. VI, No. 6, 1865, p. 12, pl. 2, fig. 14), from the Aucella beds of Spitzbergen.

Locality and position.—Abundant in the small limestone, 3 miles northwest of Paskenta, Cal., and about 3,000 feet below the top of the Knoxville beds. Thirty-one specimens were collected—nearly all with both valves united. One small specimen, doubtfully referred to the same species, was obtained from the upper part of the Knoxville, 3 miles south of Lowerys.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23051.)

ASTARTIDÆ.

Genus ASTARTE Sowerby.

ASTARTE CORRUGATA n. sp.

Pl. VI, fig. 16.

Shell very small, subtriangular, moderately convex; beaks prominent, acute; cardinal margin sloping rapidly both in front and behind; ventral margin convex, most prominent behind the middle; surface marked by a few very prominent, distant concentric ridges and by fine lines of growth; ventral margin crenulated within.

Length of largest specimen seen, 5 mm.; height, 4 mm.; convexity of single valve, about 1 mm.

This species is based on several internal casts and molds of the exterior of valves, all of about the same size, but as they are associated with many young shells of other species they also may be immature individuals. Their form and sculpture make them easily distinguishable from all other species in the Pacific Coast Cretaceous.

Locality and position.—Shelton's ranch, 5 miles north of Paskenta, Cal., in the upper part of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23052.)

ASTARTE CALIFOENICA n. sp.

Pl. VI, figs. 19-21.

Shell of medium size, subquadrate in outline, moderately convex; beaks prominent, subterminal, strongly curved forward; lunule ovate, deep, and well defined; front end descending rapidly from the beak with a concave outline above and somewhat narrowly rounded below; postero-cardinal margin sloping gently backward from the beak and joining the subtruncate posterior end by a broad curve; ventral margin broadly and regularly convex; surface marked by rounded concentric ridges, equaling or slightly exceeding the interspaces in width. A broadly rounded, somewhat obscure, umbonal ridge extends obliquely backward from the beak.

Length of the largest type, 23 mm.; height, 19 mm.; convexity of single valve, about 8 mm.

The free margins of the valves are crenulated within, and the hinge has two well-developed cardinal teeth in each valve.

In surface sculpture this species resembles *A. carlottensis* Whiteaves (Cont. to Can. Palæont., Vol. I, p. 154, and Mesozoic Fossils, Vol. I, p. 229, pl. 30, figs. 6, 6a, 6b), but its outline is very different. There is no other described species in the Lower Cretaceous of North America with which it needs to be compared.

Represented by eight valves.

Locality and position.—In the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23053.)

ASTARTE TRAPEZOIDALIS n. sp.

Pl. VI, figs. 17 and 18.

Shell of medium size, elongate subtrapezoidal in outline; beaks prominent, situated about one-third of the length behind the anterior end, which is somewhat contracted and narrowly rounded; cardinal margin behind the beaks nearly straight and parallel with the base; posterior end obliquely truncate; umbonal ridge rather prominent, broadly rounded, but fading out before reaching the postero-basal

angle; surface marked by prominent subangular concentric ridges that are somewhat narrower than the intervening furrows and by numerous fine, closely arranged lines of growth. The concentric ridges are less definite and regular in the later stages of growth, especially toward the posterior end. The lunule is deep and lanceolate in outline and the ligament is short and relatively small.

Length of the type, 25 mm.; height, 14 mm.; convexity of the two valves, 8 mm.

The elongate outline of this shell is unusual for an *Astarte*, but the other external features agree well with that genus, and internal casts (from another locality) show impressions of the hinge, which also seem to agree with it. The free margins of the shell are smooth within.

Locality and position.—The figured specimen is from the upper part of the Knoxville beds, 3 miles south of Lowerys, Tehama County, Cal. Nine other specimens, including the casts above mentioned, were collected by Mr. Jasper Palmer, jr., near Reiff, Lake County, Cal., where they occur in a limestone with *Pecten complexicosta*, *Turbo wilburensis*, etc. *Aucella crassicollis* was found near by, and the horizon is therefore regarded as about the same as at the other locality.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23054 and 23104.)

Genus OPIS Defrance.

OPIS CALIFORNICA, n. sp.

Pl. VII, figs. 1-4.

Shell of medium size, with the outline triangular when viewed from the side, and cordate in profile; beaks submedian, narrow, prominent, incurved, and approximate; surface divided by a sharply angular umbonal ridge into two distinct areas, of which the posterior one is nearly plane and so abruptly deflected that it is scarcely visible from the side view, although it embraces about one-third of the total surface of the valve; front and ventral margins regularly curved from the lunule to the end of the umbonal ridge, where it forms an angle of about 80° with the truncated and deflected posterior end; surface marked by fine lines of growth and more distant, irregular, concentric furrows; lunule cordate, large, and very deep, with its border narrowly rounded; behind the beak there is a well-defined depressed area, or escutcheon, resembling the lunule, but not quite so large nor so deep.

The hinge shows the characteristic structure of the genus, with a single very large striated triangular tooth in the right valve and two smaller ones in the left, of which the anterior is fused with the edge of the shell.

One of the eight valves in the collection is much more slender than any of the others, though it agrees perfectly with them in all other respects. This specimen (figs. 1-3) measures 27 mm. in height, 16 mm. in length, and 10 mm. in convexity. The corresponding dimensions of

the other figured specimen are 27, 20, and 11 mm., respectively. The largest valve collected is 35 mm. in height.

The genus *Opis* is very rare in American strata, only six species having been recorded from the Cretaceous, and four of that number, *O. bella* and *O. bicarinata* Conrad, *O. haleana* d'Orbigny, and *O. conradi* Gabb, are doubtful representatives of the genus. *O. vancouverensis* Whiteaves is much larger than *O. californica* and differs from it in every specific feature. *O. texana* Cragin (4th Ann. Rept. Geol. Surv. Texas, p. 196), described from an internal cast, is probably more closely related to our species, but it evidently differs in outline and other features. Under the name *Corbula triangulata*, Dr. J. G. Cooper has recently¹ described an *Opis* from the Chico beds on Point Loma, near San Diego, Cal. The figure is too poor to be recognizable, but through the courtesy of the secretary and trustees of the Mining Bureau I have been enabled to study a part of their Cretaceous collections from southern California, including this species, *Opis triangulata*, which is represented by the type and another much larger specimen. It has very nearly the outline of *O. californica*, but it has a much more strongly sculptured surface.

Locality and position.—In the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal. (National Museum Catalogue, Mesozoic Invertebrate Fossils, 23055.)

LUCINIDÆ.

Genus LUCINA Bruguière.

LUCINA OVALIS n. sp.

Pl. XII, fig. 1.

Shell large, suboval, with both ends broadly and almost equally rounded, convex; beaks rather prominent, approximate; dorsal margin excavated in front of the beaks and gently convex behind; ventral margin forming a regular broad curve; surface marked by numerous fine elevated lines of growth and by larger, more irregular, undulations.

The type specimen measures 60 mm. in length, 45 mm. in height, and 27 mm. in convexity of both valves. All but one of the eight other specimens in the collection are smaller than the type.

The generic characters of *Lucina* are very well shown by this species. The hinge has two rather large cardinal teeth, and the laterals are also well developed. The anterior adductor muscular impression is long and narrow, extending backward considerably within the pallial line. The interior of the shell is rough and irregularly striated. The ligament is large and prominent.

Locality and position.—From the small limestone, 3 miles northwest of Paskenta, and about 3,000 feet below the top of the Knoxville beds. A fragmentary specimen probably belonging to this species was col-

¹ Cal. State Mining Bureau, Bull. No. 4, p. 49, pl. 2, fig. 42, San Francisco, 1894.

lected by Mr. Storrs at about the same horizon near Cooper's, on the south fork of Elder Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23056.)

LUCINA COLUSAENSIS n. sp.

Pl. XI, figs. 4 and 5.

Shell large, elongate subovate in outline, convex; beaks prominent, approximate, situated a little in advance of the middle; dorsal margin slightly excavated in front of the beaks and sloping almost equally before and behind; anterior end broadly rounded; posterior end narrower and subangular below; ventral margin forming a broad curve; test rather thick; surface marked by numerous irregular coarse lines of growth.

Represented by two specimens, the larger of which measures 95 mm. in length, 68 mm. in height, and 40 mm. in convexity of the two valves united. The corresponding dimensions of the other specimen are 77 mm., 58 mm., and 34 mm., respectively.

This species also has a very large ligament and shows roughness and radiating striæ on the cast. The hinge and muscular impressions have not been seen, and it is referred to *Lucina* principally on account of its apparent relationship with *L. ovalis*. It is easily distinguishable from that species by its larger size, thicker test, coarser sculpture, more elongate form, and other differences in outline.

Locality and position.—The larger specimen was found associated with *Lucina ovalis* at the locality 3 miles southwest of Paskenta, Tehama County. The other was obtained in the white limestone, with *Rhynchonella whitneyi*, *Modiola major*, etc., near Wilbur Springs, on Sulphur Creek, Colusa County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23057 and 23058.)

CYPRINIDÆ.

Genus CYPRINA Lamarck.

CYPRINA OCCIDENTALIS Whiteaves.

Pl. XII, fig. 2.

Cyprina occidentalis Whiteaves, 1884, Mesozoic Fossils, Vol. I, p. 227, fig. 10 in text.

Shell of medium size, with a thick test, subovate in outline, depressed; beak broad, rather prominent, and situated considerably in advance of the middle; dorsal border descending abruptly with a concave outline in front of the beak and sloping more gently behind, where it is straight or slightly convex; anterior end rather narrowly rounded; posterior end broader and subtruncate below; ventral margin forming a regular broad curve; surface marked by prominent but somewhat irregular concentric lines.

Length, 60 mm.; height, 50 mm.; convexity of single valve, about 16 mm.

The single specimen in our collection agrees so well with Whiteaves's species in outline and general proportion that I have little hesitation in identifying it, although it is smaller than the original. The hinge is not well preserved, but it evidently had large, heavy teeth.

Locality and position.—The type of the species came from the Queen Charlotte formation on the south side of Alliford Bay, Queen Charlotte Islands. Our specimen was found in the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23059.)

SOLENIDÆ.

Genus SOLECURTUS Blainville.

SOLECURTUS ? DUBIUS n. sp.

Pl. X, figs. 4 and 5.

Shell rather small, oblong, subequilateral, depressed; dorsal and ventral margins almost parallel; anterior end broadly rounded and somewhat narrower than the posterior end, which is obliquely subtruncate above; surface marked only by irregular lines of growth. In the young shell the beak is almost exactly median, but as the shell grows the posterior end becomes proportionally more elongate.

Length of the largest specimen collected, 36 mm.; height, 20 mm.

This form is very doubtfully referred to *Solecortus*, as the hinge and other internal features are unknown.

Locality and position.—In the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23060.)

MYIDÆ.

Genus CORBULA Bruguière.

CORBULA ? PERSULCATA n. sp.

Pl. XI, fig. 3.

Shell small, subtriangular in outline; beak rather prominent; anterior end sloping rapidly from the beak, regularly rounded; postero-cardinal margin straighter and the posterior portion of the shell depressed and subtruncate; ventral margin gently convex; surface marked by fine lines of growth and by strong, regular, distant, concentric furrows, which extend posteriorly only to the obscure umbonal ridge.

Length, 5 mm.; height, 3 mm.

The generic position of this little species is somewhat doubtful, as it is known only from the type specimen, which is a cast of a left valve broken at the posterior end. Its form and surface sculpture, however, are sufficiently characteristic to make it easily recognizable.

Locality and position.—From the small limestone, 3 miles northwest of Paskenta, Cal., and about 3,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23061.)

CORBULA FILOSA n. sp.

Pl. XI, figs. 1 and 2.

Shell small, oval, convex; beaks rather prominent, a little in advance of the middle; cardinal margin sloping almost equally from the beaks in front and behind; anterior end regularly rounded and narrower than the posterior end, which is also rounded, but more prominent above than below; ventral margin forming a broad curve; surface marked by slender filiform concentric lines, with somewhat broader interspaces. Some examples show an ill-defined subangular umbonal ridge extending from the beaks to the postero-basal margin.

Length of a large specimen, 19 mm.; height, 13 mm.; convexity of single valve, about 7 mm.

A provisional name is given to this form because it can not be referred to any of the described species from related deposits on the Pacific Coast. *Corbula concinna* Whiteaves (Mesozoic Fossils, Vol. I, p. 219, pl. 29, figs. 3, 3a), from the Queen Charlotte formation, is similar in some respects, but it differs essentially in outline, especially of the posterior portion, besides being a smaller form.

Locality and position.—In the upper part of the Knoxville beds, on Cold fork of Cottonwood Creek, near Stephenson's, Tehama County, Cal. Represented by twelve specimens.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23062.)

SCAPHOPODA.

DENTALIIDÆ.

Genus DENTALIUM Linnæus.

DENTALIUM CALIFORNICUM n. sp.

Pl. XII, fig. 3.

Shell small, slender, rather strongly curved; aperture and cross section nearly circular; surface marked by about eight small angular longitudinal costæ, alternating with an equal number of fine lines.

Length of type specimen, 7 mm.; greatest diameter, 1 mm. The largest specimen seen is 11 mm. long.

This species may be distinguished from *Dentalium nanaimoense* Meek and *D. stramineum* Gabb, which occur in the Chico beds, by its smaller size, more arcuate form, and more delicate surface sculpture. It should be stated, however, that this species may be based on immature shells, since all known examples of it were found in a thin shaly layer full of a variety of small forms, some of which are certainly young shells of species that are found fully developed in adjacent strata.

Locality and position.—Upper part of the Knoxville beds on Shelton's ranch, 5 miles north of Paskenta, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23063.)

GASTROPODA.

PATELLIDÆ.

Genus HELCION Montfort.

HELCION GRANULATUS n. sp.

Pl. XII, fig. 4.

Shell depressed, conical, with the apex a little in advance of the middle and directed slightly forward; aperture elliptical; surface marked by numerous slightly wavy radiating costæ, which become somewhat broader on the posterior portion, crossed by rather closely arranged, impressed concentric lines, becoming more distant near the margin of large specimens.

The figured type measures 13 mm. in length, 9 mm. in breadth, and about 3 mm. in height. Another example that shows the surface ornamentation better, but is too much distorted by pressure for illustration, measures about three times these dimensions.

Locality and position.—Upper part of Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23064.)

FISSURELLIDÆ.

Genus FISSURELLA Bruguière.

FISSURELLA BIPUNCTATA n. sp.

Pl. XIII, fig. 8.

Shell small, elevated, conical, with the apex directed slightly forward and perforated; aperture subcircular; surface cancellated, the sculpture consisting of strong radiating ribs alternating with fine lines crossed in the interspaces between the ribs by stronger concentric lines, so that the interspaces when magnified have the appearance of radiating double rows of punctations.

The aperture of the type specimen, the only one known, measures 4 mm. by 6 mm., and its height is about $3\frac{1}{2}$ mm.

The small size of this shell suggests that it may not be a full-grown individual, but if this should prove to be true there will probably be no difficulty in recognizing the species from its general form and its strongly marked sculpture. This is the first recorded occurrence of the genus *Fissurella* in the Mesozoic strata of North America.

Locality and position.—Upper part of Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23065.)

PLEUROTOMARIIDÆ.

Genus PLEUROTOMARIA Defrance.

PLEUROTOMARIA sp.

A large species represented by a single imperfect specimen was found in the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek. It retains portions of the shell, but does not show much of the surface sculpture, though it was probably nearly smooth. The form is broadly conical, with a concave, deeply umbilicated base, on which are elevated revolving lines about 2 millimeters apart. The aperture is narrow and oblique, and the last whorl shows traces of a long narrow slit. The specimen is not well enough preserved to make an intelligible figure.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23066.)

TURBINIDÆ.

Genus TURBO Linnæus.

TURBO PASKENTAENSIS n. sp.

Pl. XII, figs. 5 and 6.

Shell of medium size, obliquely subovate; whorls, about five, regularly rounded and increasing rapidly in size, separated by a linear impressed suture; surface marked by rather distinct lines of growth and by subequal granulated revolving lines, of which there are about thirteen on the body whorl. Faint traces of these revolving lines are often visible on internal casts, especially on the body whorl of large specimens.

Height of the largest specimen seen, about 28 mm.; greatest breadth, 22 mm.

The species is represented by ten more or less imperfect casts, some of which retain enough of the shell to show the character of the surface sculpture. The aperture is not preserved in any of them, but the shell was evidently not umbilicated. It is referred to *Turbo* on account of its general form and surface sculpture, though from the material at

hand it is not possible to determine whether it had all the characteristics of that genus.

Locality and position.—Three miles northwest of Paskenta, Tehama County, Cal., in a small limestone about 3,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23067.)

TURBO WILBURENSIS n. sp.

Pl. XII, fig. 15.

Shell of medium size, elongate ovate, consisting of five or six rounded whorls; suture linear, impressed; surface ornamented with small, elevated, slightly nodulose revolving lines, of which there are about twenty on the body whorl, and about nine are visible on the spire.

Height of the largest specimen, which is incomplete at the apex, 34 mm.; greatest breadth, 25 mm.

The species is represented by three specimens from a limestone in which the surface characters are not perfectly preserved. It is rather closely related to *T. paskentaensis*, from which it differs in its somewhat more slender form and the details of surface sculpture, having more numerous revolving lines of a different character. The aperture, also, is somewhat more produced in front.

Locality and position.—In the white limestone, near Wilbur Springs, on Sulphur Creek, Colusa County, Cal., where it is associated with *Rhynchonella whitneyi*, *Modiola major*, etc. Exact position in the Knoxville beds not determined.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23068.)

TURBO TRILINEATUS n. sp.

Pl. XII, fig. 12.

Shell small, obliquely ovate, consisting of about four rapidly increasing convex whorls; surface ornamented by three elevated, equidistant revolving lines that are visible on the spire, by seven or eight fainter and more closely arranged revolving lines on the lower half of the body whorl, and by rather distinct transverse striæ that give the shell an obscurely cancellated appearance, especially on the upper whorls. The aperture is subquadrate, and the shell is not umbilicated.

Height of the type specimen, 11 mm.; greatest breadth, 10 mm.

Represented by a single specimen. In drawing the figure the artist has erroneously made four equal revolving lines on the body whorl. The lowest of these should be much fainter.

In general form this species resembles the young of *T. paskentaensis*, but it is easily distinguished by the differences in sculpture. It is perhaps more closely related to *T. colusaensis*, described below, from

which also the details of sculpture and the great difference in size will serve to distinguish it.

Locality and position.—From a small lens of limestone in the upper part of the Knoxville beds, about 3 miles north of Lowerys, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23069.)

TURBO COLUSAENSIS n. sp.

Pl. XII, fig. 14.

Shell of medium size, elongate ovate, consisting of four or five rounded whorls; surface sculpture (as seen on the cast, retaining portions of the shell), consisting of four rather prominent, nodulose, revolving ridges, three of which are visible on the spire, of finer lines alternating with the ridges and covering the anterior half of the body whorl, and of rather prominent transverse lines which by intersecting the revolving ridges on the spire give the surface a coarsely reticulate or pitted appearance. Like all the other species here referred to the Turbinidæ, this shell is not umbilicated. Full outline of the aperture not preserved.

Represented by two specimens, the larger of which measures 26 mm. in height and 20 mm. in greatest breadth.

Compared with the preceding species (*T. trilineatus*), this form is proportionally more elevated and slender, and the details of the sculpture are different, though the general type of sculpture is the same in both.

Locality and position.—In the white limestone, near Wilbur Springs, on Sulphur Creek, Colusa County, Cal., where it is associated with *Rhynchonella whitneyi*, *Modiola major*, *Pecten complexicosta*, *Turbo wilburensis*, etc. Exact position in the Knoxville beds not determined, but this limestone is evidently interstratified with shales and sandstones bearing *Aucella piochii*.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23070.)

TURBO MORGANENSIS n. sp.

Pl. XII, fig. 13.

Shell of medium size, elongate ovate, consisting of about four rather rapidly increasing convex whorls; surface of the spire marked by two strong nodose revolving ridges that give the whorls a biangular appearance, crossed on the first two whorls by smaller transverse lines connecting the nodes; body whorl in front of the two ridges bearing four or five somewhat less prominent distant revolving lines. The surface when magnified also shows fine lines of growth and numerous faint revolving lines that cover the revolving ridges as well as the interspaces. The two prominent ridges are so placed that the anterior one is about on the middle of the body whorl, while the posterior one

is near the middle of the visible portion on whorls of the spire. The portion of the whorl behind (above) the posterior ridge is a nearly smooth slope, which sometimes shows a faint nodulose revolving line near the suture.

Represented by four internal casts and two natural molds of the surface, of which the largest specimen measures 20 mm. in height and 17 mm. in greatest breadth.

The most closely related of the Knoxville forms is *T. colusaensis*, which has the same general form and style of sculpture. The sculpture in *T. morganensis*, however, is coarser; it has two revolving ridges on the spire instead of three, and the revolving lines on the front half of the body whorl are much stronger and less numerous.

Locality and position.—Morgan Valley, Lake County, Cal., 1 mile northwest of Palmer's ranch, on road from Lower Lake to Knoxville, where it is associated with *Pecten complexicosta*, *Astarte trapezoidalis*, and *Atresius liratus* in the upper part of the Knoxville beds. Collected by Mr. Jasper Palmer, jr.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23071.)

TURBO ? HUMEROSUS n. sp.

Pl. XII, figs. 10 and 11.

Shell rather small, moderately elevated, composed of four or five volutions; whorls faintly angulated by two revolving lines or small carinae, the lower of which is sometimes obsolete, and occasionally with a third line interpolated between them; posterior part of the whorls, above the upper revolving line, obliquely flattened; surface sculpture in addition to the carinae consisting of fine revolving lines, that are more prominent toward the front of the body whorl, and of lines of growth. The growth lines are sinuous, directed slightly backward from the suture to the upper carina, where they have a tendency to form small tubercles, and thence curving gently forward; aperture broadly ovate, slightly produced below.

Length of an average specimen, 14 mm.; greatest breadth, 10 mm. Some individuals are more slender than this.

The true generic position of this species is doubtful. It is represented by ten imperfect specimens, none of which show the full form of the aperture nor the character of the inner lip. In the best preserved examples the entire shell is replaced by calcite, thus retaining the sculpture in part.

Locality and position.—The figured types are from the upper part of the Knoxville beds, 3 miles north of Lowerys, Tehama County, Cal. Three specimens that seem to belong to this species were obtained in the white limestone with *Rhynchonella whitneyi*, *Modiola major*, *Turbo wilburensis*, etc., near Wilbur Springs, Colusa County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23072 and 23073.)

Genus AMBERLEYA Morris and Lycett.

AMBERLEYA DILLERI n. sp.

Pl. XII, figs. 7-9.

Shell of medium size, rather slender turbinate; whorls, about six, sharply angulated by a strong tuberculate revolving carina, which on the body whorl is slightly above the middle; upper surface of the whorls, with a plane or slightly concave slope from the suture to the carina, marked by distinct, irregular lines of growth and on some specimens by one or two faint revolving lines; the portion of the whorl below the carina is rounded, and bears about seven distinct granulated revolving lines, of which the lower ones are smaller and more closely arranged, and only the upper one is visible on the spire, where it shows as a row of small tubercles just above the suture.

The species is represented by eighteen more or less fragmentary specimens, from which it is evident that adult shells measured not less than 35 mm. in height and about 25 mm. in greatest breadth.

Forms similar to this are referred by Fischer to the genus Amberleya, which was based on certain Oolitic species from England. In Zittel's Handbuch der Palæontologie, Amberleya is not recognized, because it is stated that the genus was not fully characterized, and the same forms are referred to Eunema. The Jurassic fossils belonging to this group were included by d'Orbigny in his genus Purpurina, and some of the species figured by him seem to be closely related to our California fossils. *Purpurina belia* (Pal. Fran. Terr. Jur. II, pl. 330, figs. 9, 10) especially has a very close resemblance to it in form and sculpture, and *P. ornata*, figured on the same plate, has almost exactly the same ornamentation as a fragment associated with the other specimens just described.

A species that seems to belong to the same group has been collected by Dr. Cooper Curtice in the Mariposa beds on Stanislaus River, opposite Bostwick's Bar, but it differs too much in details of sculpture to require minute comparison with this Knoxville form.

Locality and position.—From a small limestone, about 3,000 feet below the top of the Knoxville beds, 3 miles northwest of Paskenta, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23074.)

Genus ATRESIUS Gabb.

ATRESIUS LIRATUS Gabb.

Pl. XI, fig. 6.

Atresius liratus Gabb, 1869, Palæont. California, Vol. II, p. 169, pl. 28, fig. 50.

Original description.—"Shell small, thin, elongate; spire elevated, number of whorls unknown; whorls regularly convex, suture linear. Surface marked by about fourteen or fifteen subacute revolving ribs with concave interspaces, the space between the upper rib and the

suture twice as broad as those below; first rib minutely crenulated; the whole surface crossed by fine but distinct lines of growth. Aperture subovate, a little produced and subangular in front; outer lip simple, thin, and showing faint traces internally of the ribs on the surface; columella curved."

The type was a broken and apparently immature specimen "from the Shasta group, Colusa County, southeast of Hot Sulphur Springs." The fossils that I refer to the same species show considerable variation and are more nearly complete than the original. From these the following additional descriptive notes are drawn:

The whorls, which are six or seven in number, are regularly convex in some specimens, as in the type, while others are distinctly bicarinate, on account of the enlargement of the upper rib and the fourth one below it. In extreme cases the whorl is flattened between these two carinae, but there are all variations between this extreme and the regularly rounded form with equal revolving lines. Usually only five lines are visible on the spire, but in a few specimens this number is almost doubled by the intercalation of intermediate lines.

Represented in the collection by about twenty-five specimens, one of the largest of which measures 32 mm. in height and 18 mm. in greatest breadth.

The family affinities of this shell are rather doubtful. Gabb thought that it belonged to the Littorinidae, but to me its relations seem to be rather closer with the Turbinidae.

Locality and position.—The type came from southeast of Hot Sulphur Springs, Colusa County, Cal.; that is, from the neighborhood of Wilbur Springs, on Sulphur Creek, and therefore most probably from the Knoxville beds. The specimens I have studied, including the one figured, were collected by Mr. Jasper Palmer, jr., in limestone of the upper part of the Knoxville, 1 mile northwest of Palmer's ranch, Lake County, Cal., where it is associated with *Pecten complexicosta*, *Astarte trapezoidalis*, and *Turbo morganensis*. *Aucella crassicollis* was found in the shales near by.

The fossils from the Horsetown beds on Cold fork of Cottonwood Creek, that were doubtfully referred to this species in a previous publication,¹ belong to a distinct, undescribed species.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23075.)

TURRITELLIDÆ.

Genus TURRITELLA Lamarek.

TURRITELLA sp.

A single specimen that does not fully show its specific character was collected in the upper part of the Knoxville beds, near Stephenson's, on Cold fork of Cottonwood Creek. It is a small, very slender species, with subangular whorls that are most prominent just above the suture.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23076.)

¹ Diller and Stanton, The Shasta-Chico Series, Bull. Geol. Soc. Am., Vol. V, p. 442.

PYRAMIDELLIDÆ.

Genus HYPISPLEURA Koken.

HYPISPLEURA ? OCCIDENTALIS n. sp.

Pl. XIII, figs. 3 and 4.

Shell small, slender, elongated, composed of about eight slightly convex volutions; surface ornamented by strong, curved, transverse costæ, and by very faint revolving lines crossed by lines of growth. The costæ are about ten or twelve on each whorl, slightly curved, with the convexity directed backward, largest at the upper end, which does not quite reach the linear suture above, and fading out just at the suture below, so that they do not cover the lower half of the body whorl. The most conspicuous of the revolving lines crosses the upper ends of the costæ, giving them a minutely tuberculate appearance.

Height of an average specimen, 11 mm.; greatest breadth, 4 mm.

This species seems to belong to the Mesozoic group formerly included in d'Orbigny's genus *Chemnitzia*, for which Koken¹ has proposed the name *Hypsipleura*. *Chemnitzia ? vetusta* (Phillips), from the Great Oolite of England, has a close resemblance to our species.

Locality and position.—Abundant in the small limestone, 3 miles northwest of Paskenta, Cal., and about 3,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23077.)

HYPISPLEURA GREGARIA n. sp.

Pl. XIII, figs. 1 and 2.

Shell very small, rather slender, elongate, composed of about seven slightly convex whorls; suture impressed, linear; sculpture consisting of ten or twelve transverse costæ on each whorl extending entirely across the upper whorls of the spire, but shortened to mere tubercles forming a row on the upper margin of the last two or three whorls. Aperture obliquely ovate with a thin, sharp outer lip.

Height of an average specimen, 3 mm.; greatest breadth, a little more than 1 mm. It is possible that all the specimens collected are immature, since, in the layer of calcareous shale yielding them, there are many young shells of *Aucella crassicollis*, etc., but no larger individuals referable to this species were found.

This form is easily distinguished from the preceding by its smaller size, shorter costæ, and by the absence of revolving sculpture.

Locality and position.—In the upper part of the Knoxville beds, on Shelton's ranch, about 5 miles north of Paskenta, Tehama County, Cal., where it is very abundant in a single thin layer of shale.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23078.)

¹ Zeitschr. deutsch. geol. Gesellschaft, Bd. XLIV, p. 201.

CERITHIIDÆ.

Genus CERITHIUM Adanson.

CERITHIUM PASKENTAENSIS n. sp.

Pl. XIII, figs. 5 and 6.

Shell small, composed of about five convex whorls, increasing rather rapidly in size; sculpture consisting of about twelve strong, transverse costæ on each whorl, crossed by fine, closely arranged revolving lines, of which nine or ten are visible on the spire; aperture elongate ovate, angular above and produced into a short canal below.

Height, 10 mm.; greatest breadth, 4 mm.

Locality and position.—From the small limestone, about 3,000 feet below the top of the Knoxville beds, 3 miles northwest of Paskenta, Cal. Represented by only the two imperfect specimens figured.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23079.)

CERITHIUM STRIGOSUM n. sp.

Pl. XIII, fig. 7.

Shell small, slender, consisting of nine or ten rounded whorls, surface ornamented by narrow, elevated, transverse costæ and by revolving lines. There are eight costæ on each whorl, so arranged that they form continuous varices the full length of the shell. Four of the revolving lines are visible on the spire.

Height, 6mm; greatest breadth, 2mm.

The species is known only from a natural mold of the outer surface, which does not show the form of the aperture.

Locality and position.—Shelton's ranch, 5 miles north of Paskenta, Cal., where it is associated with *Hypsipleura gregaria*, *Aucella crassicollis*, etc., in a layer of calcareous shale near the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23080.)

CERITHIUM sp.

The collection from the upper part of the Knoxville beds, near Stephenson's, on Cold fork on Cottonwood Creek, contains fragments of another species of Cerithium, very distinct from those above described. It is a slender form with flattened whorls, ornamented by strong nodose revolving lines. The material is not sufficient to characterize it fully.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23081.)

APORRHAIIDÆ.

Genus APORRHAIIS Dillwyn.

APORRHAIIS sp.

Cf. *Helicaulax bicarinata* Gabb, 1869, Palæont. California, Vol. II, p. 166, pl. 27, fig. 47.

Shell robust fusiform, consisting of four or five rapidly increasing whorls, which are obliquely flattened, so that the sides of the spire form a continuous slope; body whorl with two distinct carinæ, of which only the upper one is represented on the spire by a rather prominent raised line; surface also marked by numerous fine revolving lines; posterior canal extending to the apex of the spire; outer lip broadly expanded and wing-like, but its full outline and the anterior canal not preserved.

Height of a specimen, imperfect at both extremities, 24mm; diameter of body whorl, exclusive of expanded outer lip, 19mm.

The single imperfect specimen thus described was originally referred¹ to *H. bicarinata*, but after making more critical comparisons with the type of that species in the Philadelphia Academy of Sciences and with other collections from the Horsetown beds on Cottonwood Creek and in Tehama County, I think that it is a distinct species, though probably closely related.

The description and figure of *H. bicarinata* is slightly inaccurate. The whorls of the spire are distinctly angular, instead of plane, as shown in Gabb's figure. Better preserved specimens from the original locality in the Horsetown beds of Cottonwood Creek show that the wing has two long, slender processes, and the anterior canal also is slender and curved. It seems, therefore, to belong nearer to the typical *Aporrhais* than to *Helicaulax*.

Locality and position.—The specimen here described was collected by Mr. Storrs in the uppermost layers of the Knoxville beds, about 2 miles north of Lowerys, Tehama County, Cal.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23082.)

CEPHALOPODA.

AMMONOIDEA.

Genus PHYLLOCERAS Suess.

PHYLLOCERAS KNOXVILLENSIS n. sp.

Pl. XIV, figs. 1-4.

Cf. *Ammonites ramosus* (Meek) Gabb, 1864, Palæont. Cal., Vol. I, p. 65, pl. 11, fig. 12, 12a, and pl. 12, fig. 12b.

Not *Phylloceras* ? *ramosus* Meek, 1857, Trans. Albany Inst., Vol. IV, p. 45, and Bull. U. S. Geol. Surv. Terr., Vol. II, p. 371, pl. 5, figs. 1, 1a, 1b.

Shell rather large, discoid, moderately compressed, involute, with very small umbilicus; sides slightly convex; abdomen rather narrowly

¹ Bull. Geol. Soc. Am., Vol. V, p. 447.

rounded; surface ornamented by numerous, closely arranged, slightly flexuous linear ribs that begin as very fine lines at the umbilicus and increase in size to the abdomen, where they are slightly curved forward and are somewhat more narrow than the interspaces. The type specimen also shows several well-marked periodic constrictions.

The septa are closely crowded and very complex, the details being better shown in the tracing (fig. 3) than in a verbal description.

Greatest diameter of type, which is septate throughout, 112 mm.; height of aperture, 66 mm.; greatest breadth of same, 34 mm. Fragments from the same locality show that the species attained a much larger size.

A number of small specimens, like the one represented by fig. 4, have been collected at several localities in the Knoxville beds, and as they have about the same proportions as this species they are probably immature specimens of it. Being internal casts, the surface appears smooth, but the one figured retains faint remnants of the sculpture, consisting of fine lines.

It is with some hesitation that a new name is proposed for this form, though it is evidently distinct from Meek's *Ammonites ramosus*, which was based on a specimen from Comox, Vancouver Island. A comparison of the type of *A. ramosus* with *Phylloceras knoxvillensis* shows that the former is slightly more compressed, the umbilicus is proportionally somewhat larger, and there are no constrictions on the cast. The surface sculpture of both species consists of numerous fine lines, but they are more flexuous in *A. ramosus*, curving strongly forward near the umbilicus, while in *P. knoxvillensis* they are almost straight in that region. There are also important differences in the details of the septa, which are considerably more complex and finely divided in *A. ramosus* than in our form, although the latter is a much larger specimen. This difference is especially noticeable in the small siphonal saddle, which is deeply incised in the Vancouver species and almost simple and entire in *P. knoxvillensis*. The great difference in geological horizon of the two forms is also worthy of consideration, *P. knoxvillensis* occurring well down in the Knoxville beds and *A. ramosus* in the upper Cretaceous Chico beds. All the other species described from Comox, Vancouver, certainly belong to the Chico fauna, and, although *A. ramosus* has not been reported from Californian Chico beds, it has recently been discovered in the lowest Chico or uppermost Horsetown beds of southern Oregon by Mr. F. M. Anderson, through whose courtesy I have been permitted to examine a characteristic specimen and some of the interesting species associated with it.

Whiteaves¹ has treated *A. ramosus* as a synonym of *Phylloceras velledeæ* Michelin, and this is a reasonable identification if all the European and Indian fossils figured under this name really belong to

¹ Mesozoic Fossils, Vol. I, pt. 2, p. 103.

one species. Quite recently, however, De Grossouvre¹ has proposed a new generic as well as specific name for the English Upper Cretaceous form that has been referred to *Phylloceras velledæ*. Until direct comparison of authentic European specimens of *P. velledæ* with these west coast fossils can be made I prefer to use Meek's name.

The form from Cottonwood Creek, Shasta County, Cal., referred by Gabb to *A. ramosus* in Palæontology of California, is also distinct from that species, though Meek himself acquiesced in the identification after seeing Gabb's sketches of his fossil. Near the original locality, in the neighborhood of Ono, on Cottonwood Creek, it is found only in the lower part of the Horsetown beds, where it is quite abundant. Gabb's figure shows a somewhat thicker, more convex form than any I have seen from there, and the details of the septa are not very accurate. It is much larger than any specimen of *P. ramosus* yet collected from the Chico and the sculpture is proportionally finer. The septum differs from that species in all its details, being much more like the septum of the type of *P. knoxvillensis*, though not quite so complex in the specimens I have examined. It also differs from *P. knoxvillensis* in its finer, less conspicuous sculpture, its somewhat more compressed form, and the entire absence of periodic constrictions. Perhaps these specimens from the Horsetown beds are only a variety of the Knoxville species—they are certainly closely related—but until the two forms are found in the same strata, and until the intermediate forms are found, it seems to me useful to treat them as distinct species, and I therefore propose the name *Phylloceras onoensis* for the Horsetown form. We then have three successive species, probably genetically related, in the Cretaceous of the Pacific Coast, viz: *P. knoxvillensis* n. sp. in the Knoxville, *P. onoensis* n. sp. in the Horsetown, and *P. ramosus* Meek in the Chico.

The generic reference of these species is not entirely satisfactory, because the saddles do not have the well-developed phylliform terminations characteristic of typical species of *Phylloceras*. (Unfortunately my figure of the septum exaggerates this difference.) It seems to me, however, that their relations are closer with *Phylloceras* than with *Desmoceras*, to which somewhat similar forms have sometimes been referred. Possibly *P. ramosus* could be included in Grossouvre's genus *Schlüteria*, which seems to have been intended for Upper Cretaceous species only, but the three species are too closely related to permit their generic separation.

The figures of *Placenticeras fallax* Castillo and Aguilera² from the Aucella beds of Catorce, Mexico, show great resemblance to this species, excepting that the umbilicus is somewhat wider in the Mexican form.

Locality and position.—The type of *P. knoxvillensis* was collected by Mr. Cooper, about 1 mile northwest of his ranch, on the south fork of Elder Creek, Tehama County, Cal. The large fragments mentioned

¹ Les Ammonites de la Craie supérieure, p. 216, Paris, 1893.

² Boletín de la Comisión Geológica de México, No. 1, p. 17, pl. 8, figs. 1, 2, Mexico, 1895.

in the description and a small young specimen were collected by Mr. Storrs at the same place, where it is associated with *Aucella piochii*, *Hoplites storrsi*, etc. The horizon is about 3,000 feet below the top of the Knoxville beds. The small specimen figured is from the small limestone, on about the same horizon, 3 miles northwest of Paskenta. Similar small specimens have been collected in the neighborhood of Knoxville, Napa County, and near Wilbur Springs, Colusa County.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23083 and 23084.)

Genus LYTOCERAS Suess.

LYTOCERAS BATESI (Trask).

Pl. XIII, figs. 9-11.

Ammonites batesii Trask, 1855, Proc. Cal. Acad. Sci., Vol I, p. 40.

Ammonites batesii Gabb, 1864, Palæont. Cal., Vol. I, p. 67, pl. 13, figs. 16a, 16b.

? *Ammonites batesii* Gabb, 1869, Palæont. Cal., Vol. II, p. 132, pl. 20, fig. 9a, pl. 21, figs. 10a, 10b.

Ammonites crenocostatus Whiteaves, 1876, Mesozoic Fossils, Vol. I, p. 45, pl. 9, figs. 2, 2a.

Lytoceras batesi Whiteaves, 1884, Mesozoic Fossils, Vol. I, p. 202, pl. 27, fig 1.

This well-known species has been sufficiently described by the authors above referred to. It shows considerable variation in form, especially in the relative rapidity of increase by growth in the diameter of the whorls, and there is some variation in the amount of involution. I think, however, that the limits of the species should be more restricted than Gabb believed, and that it should not be made to include the form figured in volume 2 of the Palæontology of California, in which the earlier whorls are angular on the sides.

Well-preserved specimens nearly all show the crenulated costæ described by Whiteaves in *A. crenocostatus*, which he afterwards referred to *L. batesi*.

The peristome is greatly thickened and reflected in this species. This feature is indicated by the periodic constrictions on the internal cast, and it is well shown by a fragment of a large specimen recently collected in the Lower Horsetown beds, near Paskenta, Cal. (See Pl. XIII, figs. 9 and 10.) The whorl from which this fragment came was nearly 4 inches in diameter, and the whole shell must have exceeded a foot in diameter. The shell near the aperture has a thickness of 3 millimeters, which increases suddenly to 5 or 6 millimeters, and this thickened portion is abruptly reflected, first inward and then outward, so that a cross section of it has a narrow U-shape. The trumpet-shaped aperture of *Lytoceras immane* as described and figured by Neumayr¹ is of the same type, but somewhat more simple, as the peristome is only slightly reflected and expanded outward.

Locality and position.—The fragment showing part of the aperture is from the Lower Horsetown beds, about 3 miles north of Paskenta. The other figured specimen is from the Upper Knoxville beds, on Wil-

¹ Beiträge zur Paläontologie Oesterreich-Ungarns, Bd. III, pp. 101-103, Taf. 20, figs. 1-3, Wien., 1888.

cox's ranch, about 3 miles farther north. It is not uncommon at this horizon. Fragmentary specimens of the same or a closely related species have been collected much lower in the Knoxville beds, on south fork of Elder Creek, associated with *Aucella piochii*. It is most abundant and best preserved, however, in the Lower Horsetown beds, in Shasta and Tehama counties, from the north fork of Cottonwood Creek southward; also at Riddles, Oreg.; in Queen Charlotte Islands, etc.

Gabb also reports it from two localities in the Chico group, but this is probably an error in identification, as it has not been found in any of the later collections from those beds, and there are other forms there that, when not well preserved, might be mistaken for it.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23085 and 23086.)

Genus DESMOCERAS Zittel.

DESMOCERAS CALIFORNICUM n. sp.

Pl. XV, figs. 6 and 7.

Shell large, discoid, composed of rather narrow, slightly embracing, flattened whorls; abdomen rather broadly rounded; surface marked by slender, slightly curved ribs that cross the abdomen, but are somewhat less prominent there than on the sides. The ribs are usually simple, and are directed slightly forward in crossing the abdomen, but occasionally one bifurcates on the outer third of the side. The cast also shows occasional moderately deep periodic constrictions. Septa distant and not very complex, as shown in the tracing, distinguished especially by the very broad siphonal lobe.

The full dimensions of the species are not known, but the fragments that we have must have belonged to a specimen fully 10 inches in diameter. The largest whorl figured measures 45 mm. in height and 27 mm. in breadth. About half of each of the inner volutions is exposed in the umbilicus.

In general form this species is suggestive of Gabb's original figure of *A. breweri* (Palæont. Cal., Vol. I, pl. 10, fig. 7), but it differs from that figure in having smaller, much straighter, and more closely arranged ribs. Besides, as Gabb remarked, *A. breweri* "was originally described from several imperfect casts in sandstone, showing nothing but the surface characters and not all of those in a perfectly satisfactory manner," and "so distorted as to render it impossible to ascertain the shape of the section of a whorl, or even to show the amount of enveloping of the whorls." It is very probable, therefore, that Gabb was right in referring to this species the more perfect specimens from the same locality that are described and figured in the second volume of Palæontology of California. These are much more involute than the original figure and are not at all closely related in either form or septa to *Desmoceras californicum*, which has been compared with the large collection of *A. breweri* from Horsetown.

Locality and position.—About 3 miles north of Paskenta, Cal., and one-half mile east of Henderson's, associated with *Aucella crassicollis*, var., in beds about 1,500 or 2,000 feet below the top of the Knoxville. Represented by three other fragments besides those figured, probably all belonging to one individual. Collected by Mr. Storrs.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23087.)

DESMOCERAS ? sp.

Another species probably belonging to this genus is represented by several fragments from the uppermost Knoxville beds, from 2 to 4 miles north of Lowerys, Tehama County, Cal. It is much more involute than the preceding species, and is marked by numerous rather closely arranged ribs.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23088.)

Genus OLCOSTEPHANUS Neumayr.

OLCOSTEPHANUS (SIMBIRSKITES) MUTABILIS n. sp.

Pl. XV, figs. 1-5.

- Cf. *Olcostephanus discofalcatus* Lahusen, Verhandl. Russ. Kais. Min. Gesellschaft, 2d ser., Bd. IX, p. 67, pl. 7, figs. 2-4; Pavlow, Bull. Soc. Nat. Moscou, 1890, pl. 6, fig. 1; Idem, 1891, pl. 18, fig. 2.
- Cf. *Olcostephanus quatsinoensis* Whiteaves, Trans. Roy. Soc. Canada, Vol. I, sec. 4, p. 82, fig. 1, and *Scaphites quatsinoensis* Whiteaves, Cont. Can. Palæont., Vol. I, p. 158, pl. 21, fig. 2.
- Cf. *Olcostephanus potosinus* Castillo and Aguilera, 1895, Boletín de la Comisión Geológica de México, No. 1, p. 36, pl. 7, fig. 2.

Shell rather small, discoid, involute; volutions narrowly rounded on the abdomen, slightly convex on the sides, and regularly rounded into the umbilicus, in which only a small portion of the preceding whorl is visible; surface ornamented by narrow, prominent, slightly sinuous ribs that originate on the margin of the umbilicus, usually divide about the middle of the side into two to four branches, and thence cross the abdomen, where they are strongly curved forward. The ribs vary greatly in different specimens and at different stages of growth in the same specimen. In one of those figured the most of the ribs simply bifurcate once, though occasionally one divides into three branches, and a few are simple; but on the outer third of the last whorl the ribs starting from the umbilicus are larger and more widely separated, and after passing about half way across the side they are each broken up into four or five small ribs, so that on the abdomen the ribs are finer and more closely arranged than they are in the same region of the earlier portions of the shell. In some of the specimens this style of sculpture seems to be developed at an earlier stage, while in others nearly all the ribs trifurcate, but after studying a series of about forty specimens I can not make these variations of specific importance. Internal casts also show several periodic constrictions on each volution.

The larger of the figured specimens is about of the average size, though it is septate throughout. Its dimensions are: Greatest diameter, 52 mm.; umbilicus, 11 mm.; end of last volution, 26 by 16 mm. All the specimens are more or less distorted, and none shows the complete septum clearly. The enlarged sketch (fig. 2) shows pretty accurately the form of the septum, excepting the siphonal lobe, which was not seen on any of the specimens.

The Russian species with which I have compared this one, and which seems to be really very closely related, comes from the Neocomian of Simbirsk and Worobiewo, and is also reported from England. It belongs to the group of *Olcostephanus*, for which Pavlow has proposed the name *Simbirskites*.

Scaphites quatsinoensis Whiteaves, which was originally described as an *Olcostephanus*, comes from the same horizon as our species on the northern end of Vancouver Island, and in size, general form, and style of ornamentation, especially in the variations described in the later publication referred to, it is quite comparable with *O. mutabilis*, but this resemblance is probably only superficial, as our specimens certainly are not *Scaphites*.

The fragmentary specimen of *Olcostephanus potosinus* Castillo and Aguilera, from the Aucella beds of Catorce, Mexico, shows the same type of sculpture as *O. mutabilis*.

Locality and position.—On Shelton's ranch, 5 miles north of Pas-kenta, Cal., in the upper part of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23089.)

OLCOSTEPHANUS (POLYPTYCHITES) TRICHOTOMUS n. sp.

Pl. XVI, fig. 1.

Cf. *Ammonites polyptychus*, Keyserling, 1864, *Reise in das Petschora-Land*, p. 327, pl. 21, figs. 1-3, and pl. 22, fig. 9.

Shell rather large, moderately involute, with rounded whorls that are nearly as broad as high; surface ornamented by strong, slightly curved ribs that arise on the edge of the umbilicus and divide about the middle of the side into two branches, the posterior of which usually again soon divides. On the abdomen these divided ribs are about half as broad as the interspaces.

The specimen in hand is so badly crushed and distorted that a full specific description can not be given, but the surface sculpture will readily distinguish it from all of its associates and make it easily identifiable when good specimens are found.

Ammonites polyptychus, which Eichwald regarded as a synonym of *A. bidichotomus*, seems to be a closely related species, but is apparently somewhat more involute. This and several similar forms from the lowest Cretaceous and uppermost Jurassic beds of Europe are grouped together by Pavlow¹ under the subgeneric name of *Polyptychites*.

¹ Pavlow and Lamplugh, *Argiles de Speeton et leurs Équivalents*, pp. 118-130 (from Bull. Soc. Nat. Moscou, 1891).

Locality and position.—Two miles south of Lowerys, Tehama County, Cal., in the uppermost layers of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23090.)

Genus HOPLITES Neumayr.

HOPLITES HYATTI n. sp.¹

Pl. XVI, fig. 2.

Shell of medium size, discoid, slightly involute; whorls, about four or five, flat or very gently convex on the sides, with the abdomen slightly flattened, except on the last third of the outer volution; surface marked by numerous slightly curved ribs, the most of which bifurcate on the outer third of the volution and cross the abdomen, though not quite so prominent there as on the sides. In the earlier stages of growth (so far as they can be seen in the specimen) the ribs are prominent and closely arranged, but on a part of the last volution they take on a senile character, becoming more distant, broader, rounded, and less conspicuous. The aperture has long lateral ears, 12 mm. wide, and projecting nearly an inch (22 mm.) beyond the general outline of the aperture. Septum unknown.

The greatest diameter of the type specimen is about 90 mm., and the aperture measures 30 mm. in height. The shell is somewhat flattened by pressure, but the normal breadth of the aperture in a specimen of this size is probably not more than 12 or 15 mm.

This species is related to *H. tenochi* Felix² and *H. wippei* Felix² from the Neocomian near Tlaxiaco, in the State of Oaxaca, Mexico, but it differs from both of these in the minor details of sculpture and in the form of the aperture, though in the latter feature it resembles *H. tenochi* very closely. Its nearest relative among the Knoxville forms is *Hoplites storrsi*, from which it differs sufficiently in sculpture to be easily distinguished when adult specimens are compared.

Locality and position.—West of Riddles, Oreg., on the road to the nickel mines, associated with *Aucella crassicollis*, in the upper part of the Knoxville beds. Collected by Mr. W. Q. Brown.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23091.)

HOPLITES STORRSI n. sp.

Pl. XVII, figs. 1 and 2; Pl. XVIII, fig. 5.

Shell of medium size, discoid, moderately involute, each whorl concealing about half of the preceding one; whorls very slightly convex on the sides, the greatest convexity being near the umbilicus; abdomen somewhat flattened; surface marked by numerous slender, slightly curved elevated ribs that originate on the margin of the umbilicus,

¹A note on this specimen by Professor Hyatt is published by Mr. Diller in Bull. Geol. Soc. Am., Vol. IV, p. 212, 1893.

²Palaeontographica, Bd. XXXVII, pp. 186, 187, pl. 28, figs. 1-3 and 6.

usually bifurcate a little beyond the middle of the side, and become obsolete in crossing the flattened abdomen; septa crowded and very complex, as shown in the figure.

The type specimen, which is septate throughout, measures 110 mm. in its greatest diameter, and the aperture measures 48 by 30 mm.

This species is not quite so compressed as *H. hyatti*, and the sculpture consists of narrower and more elevated ribs. It has a closer resemblance to one of Felix's figures of *H. tenochi*,¹ from the Neocomian of Mexico.

Related forms, such as *Hoplites angulicostatus* (d'Orbigny), occur in the Neocomian of Europe, and the same group of *Hoplites* is represented in the Upper Jurassic (Tithonian) by a number of species, such as *H. calis'o* (d'Orbigny), *H. carpathicus* Zittel, and others, that have a close resemblance to our species. Those from the Tithonian have recently been figured by Kilian.² A similar species has also been described by Behrendsen³ under the name *Hoplites calistoides*, from the Tithonian of the eastern slope of the Argentine Cordillera. The form from the Aucella-bearing series of Catorce, Mexico, figured by Castillo and Aguilera⁴ under the name *Hoplites calisto* var., is very closely related to *H. storrsi*, and may be identical with it. *Hoplites angulatus*, described below, is another related species, differing in details of sculpture, and slightly in proportion of whorls, as will be pointed out in describing it.

Locality and position.—One mile northwest of Cooper's, on south fork of Elder Creek, Cal., about 3,000 feet below the top of the Knoxville beds. Represented by a single specimen, which was collected by Mr. James Storrs.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23092.)

HOPLITES ANGULATUS n. sp.

Pl. XVIII, figs. 3 and 4.

Shell small, discoid, slightly involute, each volution enveloping about one-third of the preceding one; volutions flattened on the periphery, slightly convex on the sides, and descending abruptly into the broad and rather deep umbilicus; surface marked by strong curved ribs arising on the margin of the umbilicus and passing to the abdomen, where they are interrupted, or at least are less strongly marked. There is a slight tendency to form nodes on the margin of the umbilicus and also on the periphery at the other end of the ribs. Some of the ribs are simple, but more than half of them bifurcate after crossing from one-half to two-thirds of the distance from the umbilicus to the periphery.

¹ Paleontographica, Bd. XXXVII, pl. 29, fig. 1.

² Boletín de la Comisión del Mapa Geológico de España, Tomo XIX, pp. 615-626, pls. 5-10, Madrid, 1893.

³ Zeitschr. deutsch. geol. Gesellschaft, Bd. XLIII, p. 402, pl. 23, figs. 1a, 1b.

⁴ Boletín de la Comisión Geológico de Mexico, No. 1, p. 38, pl. 11, fig. 2.

There are also a few interpolated simple ribs that begin about the middle of the side. Septum unknown.

The immature figured type measures 40 mm. in its greatest diameter; the aperture is 18 mm. high and 12 mm. broad, and the umbilicus is 11 mm. in diameter.

This species is evidently related to *Hoplites storrsi*, but its whorls are proportionally somewhat more convex, its sculpture is relatively coarser, with broader and more strongly curved ribs, and the border of the umbilicus is more angular. This character of the umbilicus, with its vertical walls, will readily separate it from all the associated forms in the Knoxville beds. *Hoplites crassiplicatus* is less involute and has stronger and fewer ribs that bifurcate nearer the abdomen than in this species.

The most closely related European species that I have seen figured is *H. amblygonius* Neumayr and Uhlig,¹ from the Neocomian of Germany. Pavlow² has figured a small specimen referred to the same species from Speeton, England, which is so much like our figure that it would be difficult to point out any essential difference.

• *Locality and position.*—Shelton's ranch, about 5 miles north of Pas-kenta, Cal., where it is associated with *Olcostephanus mutabilis*, *Aucella crassicollis*, and many other forms.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23093.)

HOPLITES CRASSIPLICATUS n. sp.

Pl. XVIII, fig. 8.

Shell rather small, discoid, very slightly involute; whorls compressed, descending rather abruptly into the umbilicus and flattened on the abdomen; surface ornamented by relatively large, distant ribs that arise on the edge of the umbilicus, and nearly all bifurcate after passing over about two-thirds of the distance to the periphery, on which they are interrupted. On the inner whorls the point of bifurcation of the ribs is just visible in the umbilicus.

The species is represented by a single fragment, showing parts of three whorls, of which the larger measures 17 by 13 mm. in cross section.

This species may be distinguished from all the other Knoxville Hop-lites by its less involute form and relatively coarser, more distant ribs.

The Russian Lower Volgian *Hoplites rjasensis* Lahusen, as figured by Nikitin,³ seems to be a related species, distinguished mainly by its more involute form. In general aspect and in ornamentation of the sides *H. crassiplicatus* has some resemblance to the young of *Perisphinctes skid-gatensis* Whiteaves, from Queen Charlotte Islands, but of course they are not closely related.

¹ Palæontographica, Bd. XXVII, p. 168, pl. 36, fig. 1; pl. 37, fig. 1, etc.

² Bull. Soc. Nat. de Moscou, 1891, pl. 17, fig. 6.

³ Vestiges de la Période Crétacée dans la Russie Centrale, pl. 1, figs. 1-3.

Locality and position.—About 3 miles north of Paskenta and one-half mile east of Henderson's, associated with *Aucella crassicollis*, var., *Desmoceras californicum*, etc., in beds 1,500 or 2,000 feet below the top of the Knoxville beds.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23094.)

HOPLITES DILLERI n. sp.

Pl. XVIII, figs. 6 and 7.

Shell small, discoid, somewhat involute; whorls convex on the sides, flattened on the periphery, and regularly rounded to the broad umbilicus, whose diameter is a little more than one-third of that of the entire shell; surface ornamented by numerous slender but sharply elevated ribs that arise in the umbilicus, are almost straight for about two-thirds of the distance across the whorl, and then divide, sometimes into two, but frequently into three, branches that curve strongly forward and are interrupted by a narrow furrow on the rather broad abdomen. The details of the septa can not be determined from the specimens at hand.

The type specimen, consisting of about four septate volutions, measures 31 mm. in greatest diameter, and the aperture is 13 mm. in height by 11 mm. in breadth.

This species is easily separated from the other species of *Hoplites* in the Knoxville by its more convex volutions and by the finer ribs, many of which are trifurcate.

Locality and position.—The type was collected by Mr. J. S. Diller, 3 miles west of Lowerys, Tehama County, Cal., associated with *Aucella piochii* var. *ovata*, in beds considerably below the top of the Knoxville. A smaller fragmentary specimen was obtained by Mr. Storrs at about the same horizon, 1 mile northwest of Cooper's, on south fork of Elder Creek, and another similar specimen at a higher horizon, 3 miles north of Paskenta and one-half mile east of Henderson's.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 21573.)

Genus PERISPHINCTES Waagen.

PERISPHINCTES sp.

One, or possibly two, species that seems to belong to this genus is represented by imperfect specimens from Cooper's ranch, on the south fork of Elder Creek, Tehama County. They are too obscure for specific description.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23099.)

Genus DIPTYCHOCERAS Gabb.

DIPTYCHOCERAS ? sp.

Cf. *Diptychoceras laevis* Gabb, 1869, Palaeont. California, Vol. II, p. 144, pl. 25, figs. 21, 21a, 21b.

A number of smooth, straight fragments of an Ammonoid that seems to be identical, so far as the features are preserved, with Gabb's species,

which is common in the Horsetown beds. None of the Knoxville specimens collected shows the two or three limbs connected, though in one specimen there are two portions lying in contact and parallel that probably belong to one individual.

Locality and position.—In the Knoxville beds this form was found only on Shelton's ranch, 5 miles north of Paskenta, in the upper part of the Knoxville.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23100.)

Genus CRIOCERAS Leveillé.

CRIOCERAS LATUS Gabb.

Crioceras latus Gabb, 1864, Palæont. California, Vol. I, p. 76, pl. 15, figs. 25, 25a, 25b, and pl. 14.

A characteristic fragment of one of the outer volutions was collected from the uppermost Knoxville beds, with *Aucella crassicollis*, etc., 2 miles south of Lowerys, Tehama County. A small specimen showing the inner volution was found in the basal Horsetown beds immediately overlying the Knoxville, about 2 miles farther south. The species was originally described from the Horsetown beds, on the north fork of Cottonwood Creek, Shasta County.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23101.)

Genus APTYCHUS Meyer.

APTYCHUS ? KNOXVILLENSIS n. sp.

Pl. XVIII, figs. 1 and 2.

This fossil, which is somewhat doubtfully classified as the Aptychus of an Ammonite, is an impression of a symmetrical, gaping, bivalved body, with the two valves united throughout the entire length of the shorter diameter, but not showing any Molluscan hinge structure. In the single specimen collected the two valves join each other at an angle of about 60°. Only one valve is preserved so as to show the entire outline, which is elongate subquadrate, resembling some of the simpler forms of *Perna*. The surface is marked by obscure concentric undulations.

The larger diameter, from the line of junction of the two valves to the opposite free end, is 32 mm., and the shorter diameter, at right angles to this, is 21 mm.

Locality and position.—On road from Reed to Ryal quicksilver mines, near Knoxville, Napa County, Cal., where it is associated with *Aucella piochii*. Collected by Dr. G. F. Becker.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23095.)

BELEMNITIDÆ.

Genus BELEMNITES Lister.

BELEMNITES IMPRESSUS Gabb.

Pl. XX, figs. 1-5.

Belemnites impressus Gabb, 1864, Palæont. California, Vol. I, p. 58, pl. 9, figs. 2, 2a; 1869, idem, Vol. II, p. 129; Whiteaves, 1883, Proc. and Trans. Roy. Soc. Can., Vol. I, sec. 4, p. 82.

Guard large, moderately long, robust, subcylindrical, tapering for about one-fourth of its length to a rather blunt point; ventral side with a broad, deep furrow that is deepest about at the apex of the phragmacone and gradually fades out toward the ends of the guard; phragmacone large, with numerous short chambers, its apical angle about 18° , or in some specimens slightly greater. The apical angle of the phragmacone is about the same whether measured in transverse or dorso-ventral direction.

Length of an imperfect specimen (fig. 5), 128 mm.; greatest lateral diameter, 23 mm.; dorso-ventral diameter, 22 mm. The other specimen figured (figs. 3 and 4) has a somewhat more robust form, but evidently belongs to the same species.

This species belongs to the section Infradepressi of Pavlow,¹ which includes *B. absolutus* Fischer and *B. magnificus* d'Orbigny, of the Russian Upper Jurassic, together with a number of other Jurassic and Neocomian species, all of which are regarded by Pavlow as boreal types.

Locality and position.—Very abundant in the upper part of the Knoxville beds, and in the overlying Horsetown beds, ranging through several thousand feet of strata. All of the specimens figured are from the Lower Horsetown beds, because it happens that all of the best preserved examples in our collection are from that horizon. Fig. 1 represents a specimen from the Bald Hills, near Wilcox's, Tehama County, and all the others are from the neighborhood of Ono, on the north fork of Cottonwood Creek, Shasta County, Cal. Many fragmentary specimens, well enough preserved for identification, were collected with *Aucella crassicollis* on Shelton's ranch, north of Paskenta; at the locality 2 miles north of Lowerys, Tehama County, and elsewhere.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23096 and 23097.)

BELEMNITES TEHAMAENSIS n. sp.

Pl. XIX, figs. 1-3.

Guard very long, slender, subcylindrical, tapering gradually to an acute point; ventral side with a very shallow, faint groove that begins near the point and, in passing up on the guard, broadens until it is

¹ Argiles de Speeton, pp. 89-95, from Bull. Soc. Nat. de Moscou, 1891.

represented only by a flattening of the ventral surface; section subcircular; apical angle of phragmacone, as determined from fragment showing part of alveolar cavity, about 25° .

Length of type specimen, which does not contain any part of the alveolus, 137 mm.; diameter of anterior end, 18 mm.

This species belongs to the same section as *B. impressus*, from which it is easily distinguishable by its much more slender form, greater length, more acute apex, and more nearly circular cross section. There is a related species (*B. inaequilateralis* Eichwald ?) in the National Museum from the Aucella-bearing beds of Herendeen Bay, Alaska, and similar forms occur in the Upper Jurassic of Europe, such as *B. obeliscoides* Paylow.

Locality and position.—Abundant near Cooper's ranch, on the south fork of Elder Creek, Tehama County, Cal., and at the same horizon elsewhere in that region, associated with *Aucella piochii* var. *ovata*.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23098.)

BELEMNITES sp.

In the upper part of the Knoxville beds there is another species of Belemnites, represented in our collections by fragments. It apparently has about the form of *B. tehamaensis*, but the alveolus, with an apical angle of about 26° , is inclined toward the ventral side so that its apex is midway between the center and the ventral side, making the axis of the guard very eccentric.

This form occurs on Shelton's ranch, 5 miles north of Paskenta, Cal., associated with *B. impressus*, *Aucella crassicollis*, *Olcostephanus mutabilis*, etc.

(National Museum Catalogue, Mesozoic Invertebrate Fossils, 23103.)



PLATES.



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All figures on this plate are natural size.

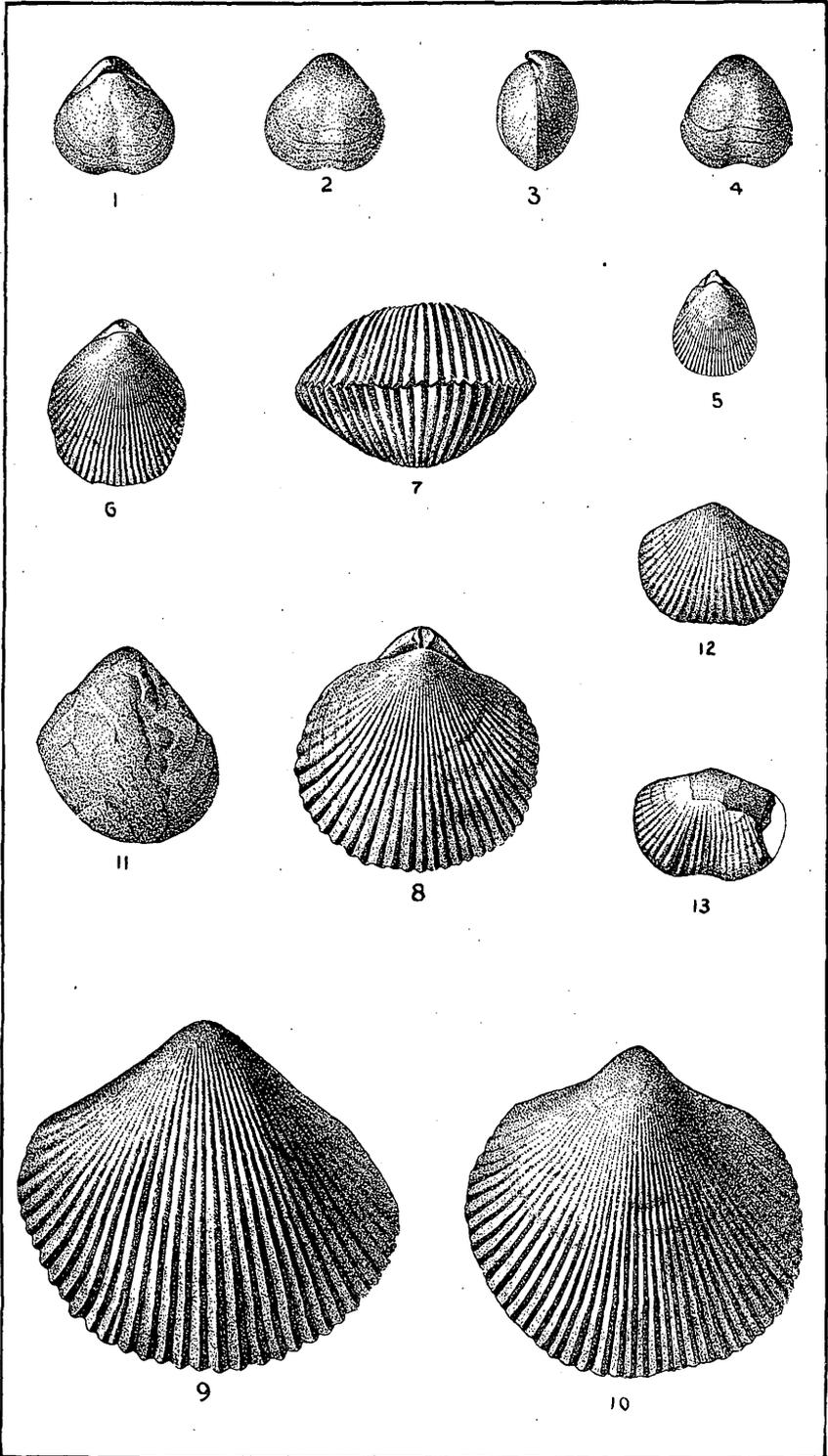
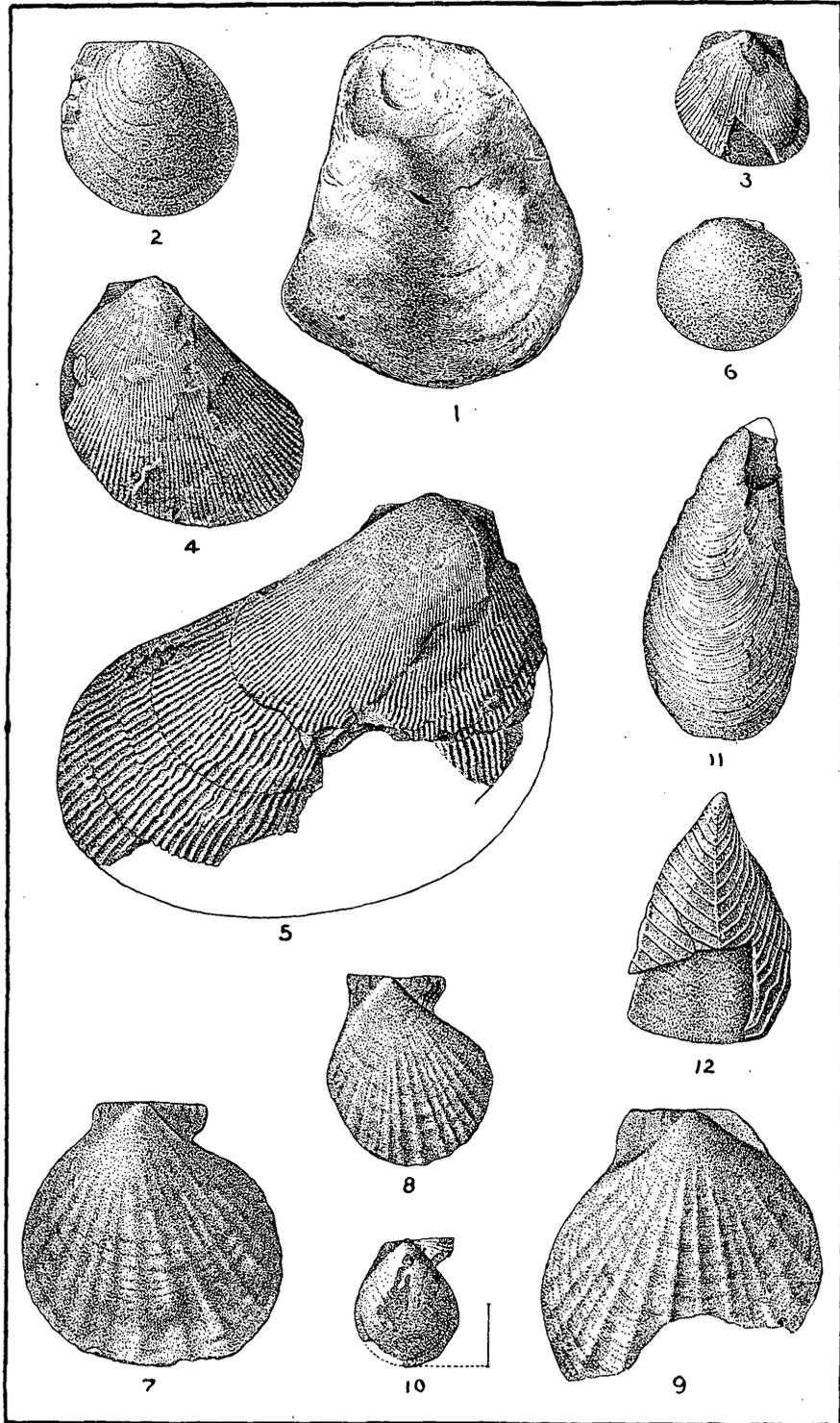


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Unless otherwise stated the figures are natural size.	



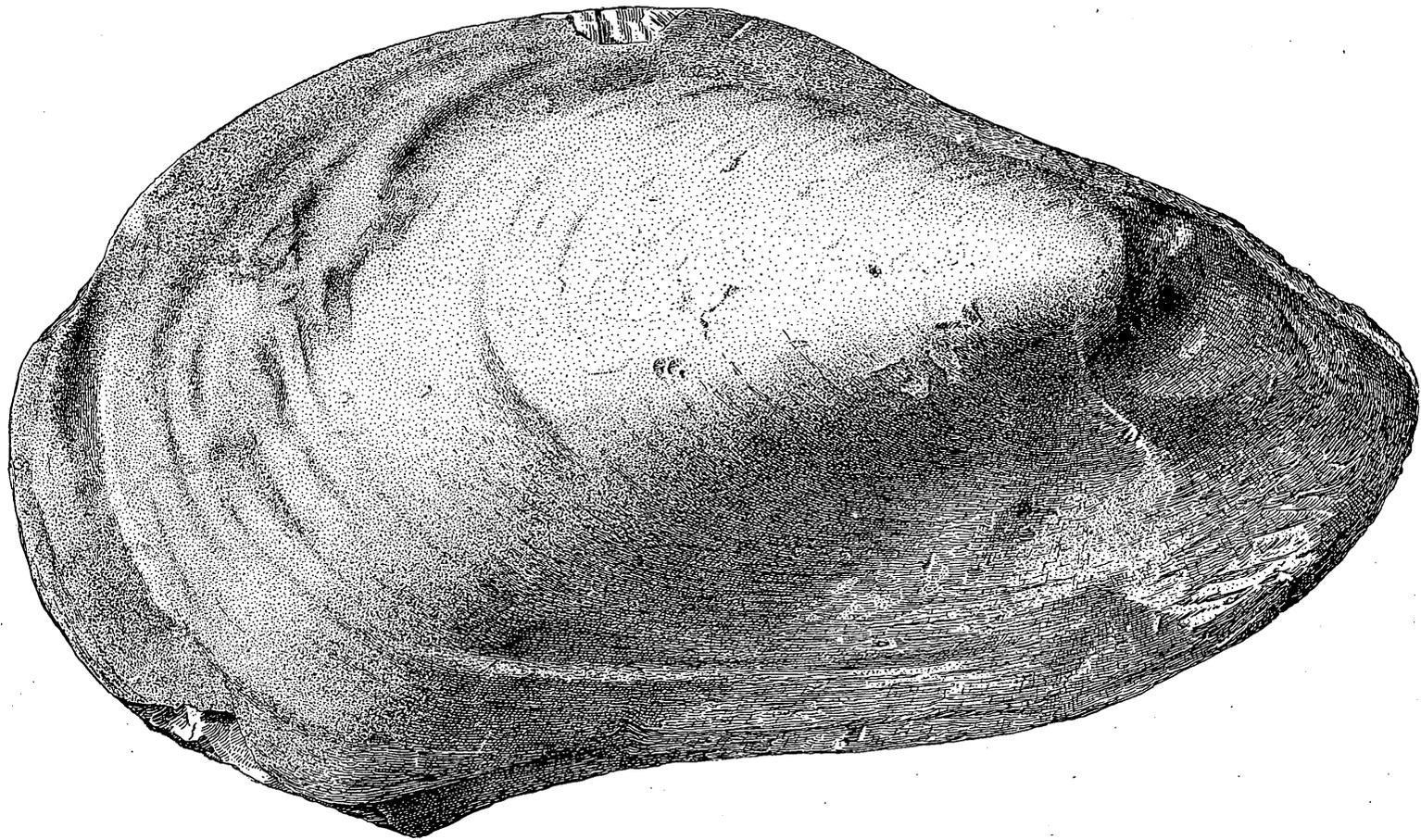
PELECYPODA: OSTREIDÆ, ANOMIIDÆ, SPONDYLIDÆ, LIMIDÆ, PECTINIDÆ, MYTILIDÆ, AND PINNIDÆ.

PLATE III.

PLATE III.

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size.

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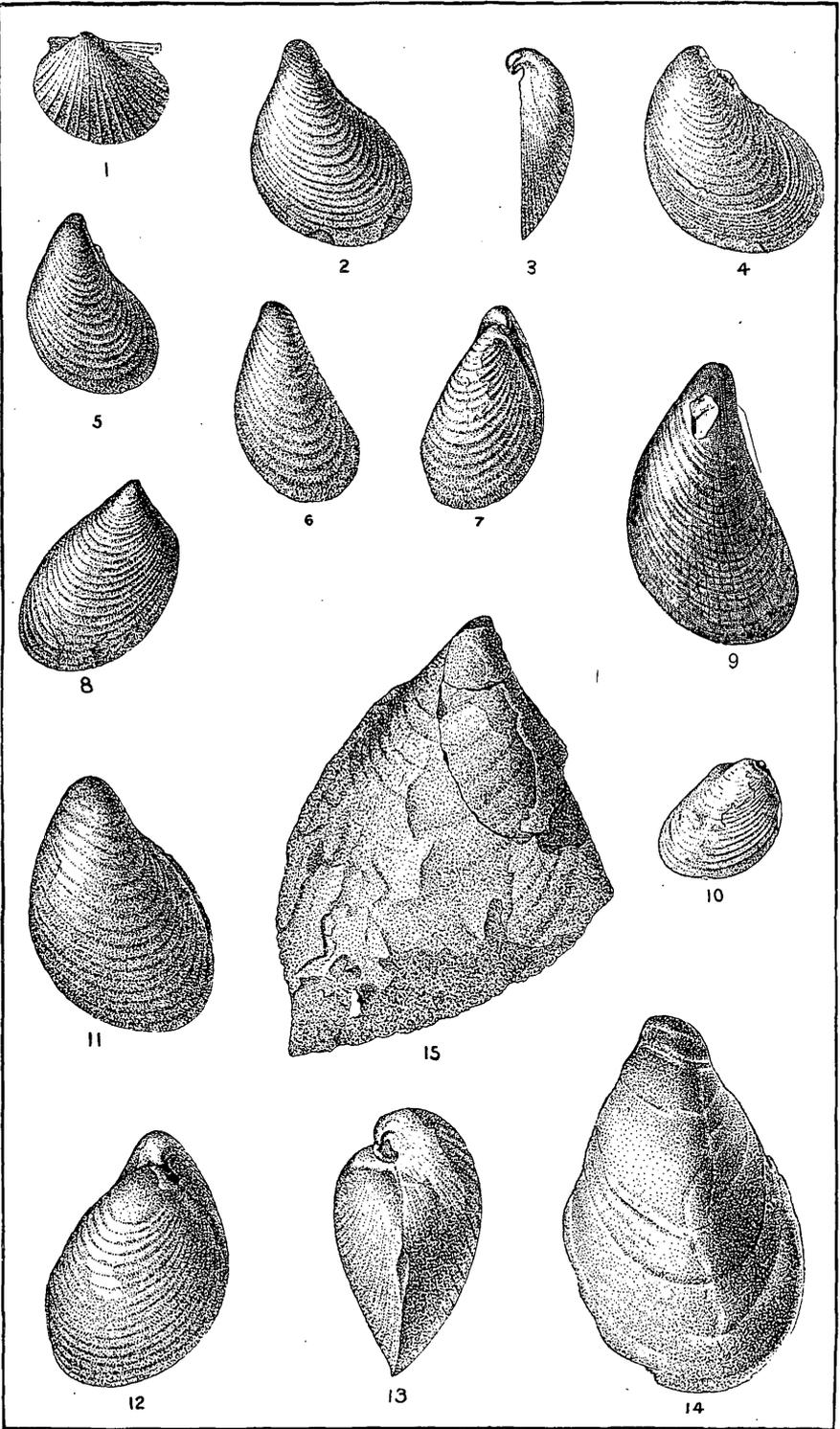
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All figures natural size.



PELECYPODA: AVICULIDÆ.

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45

AUCELLA CRASSICOLLIS Keyserling.....

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Fig. 7. Hinge of left valve.

Fig. 8. A small, slender left valve.

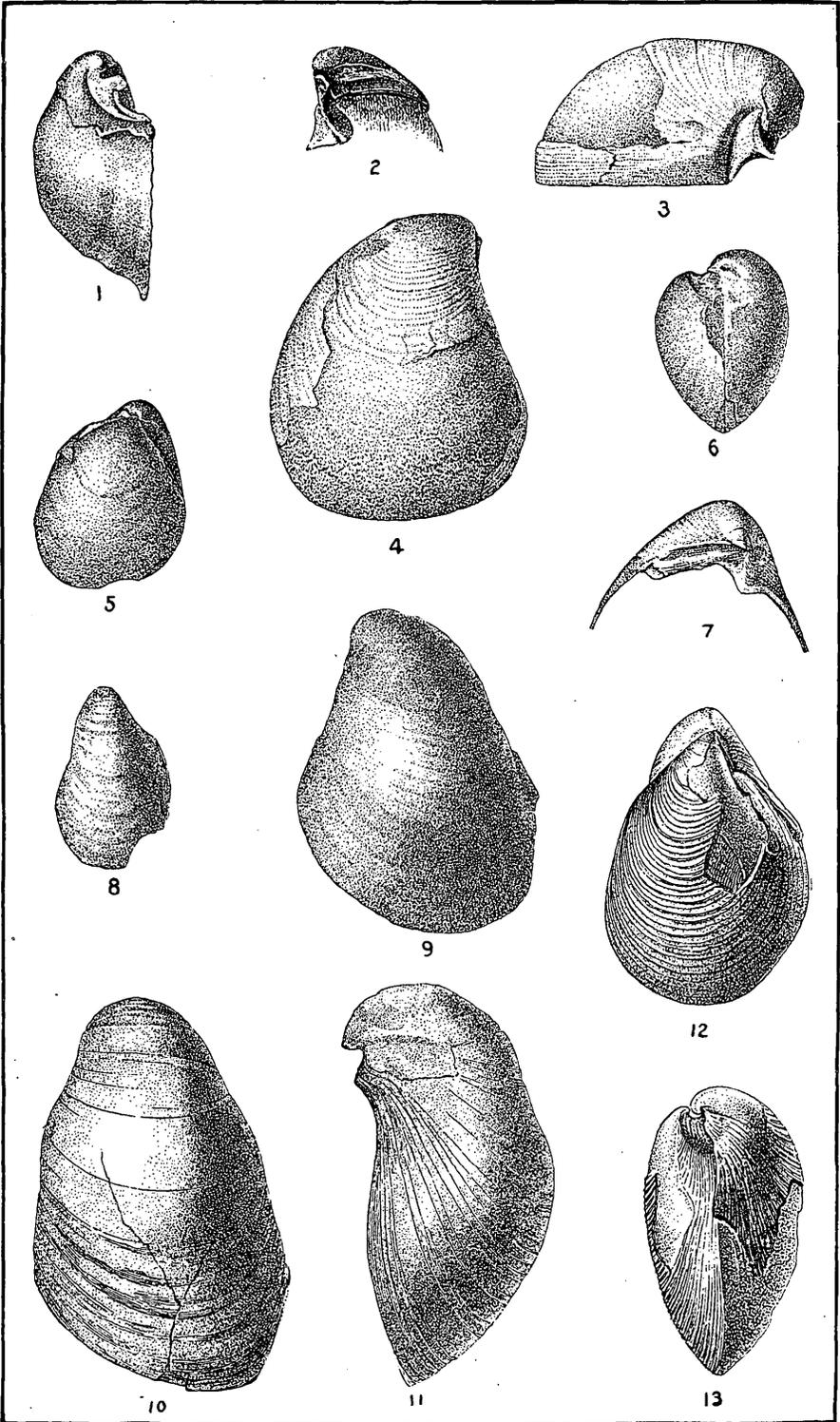
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Figs. 12, 13. Right and profile views of a specimen that approaches *A. piochii* var. *ovata* in form.

(See additional illustrations of this species on Pl. VI.)

All figures natural size.

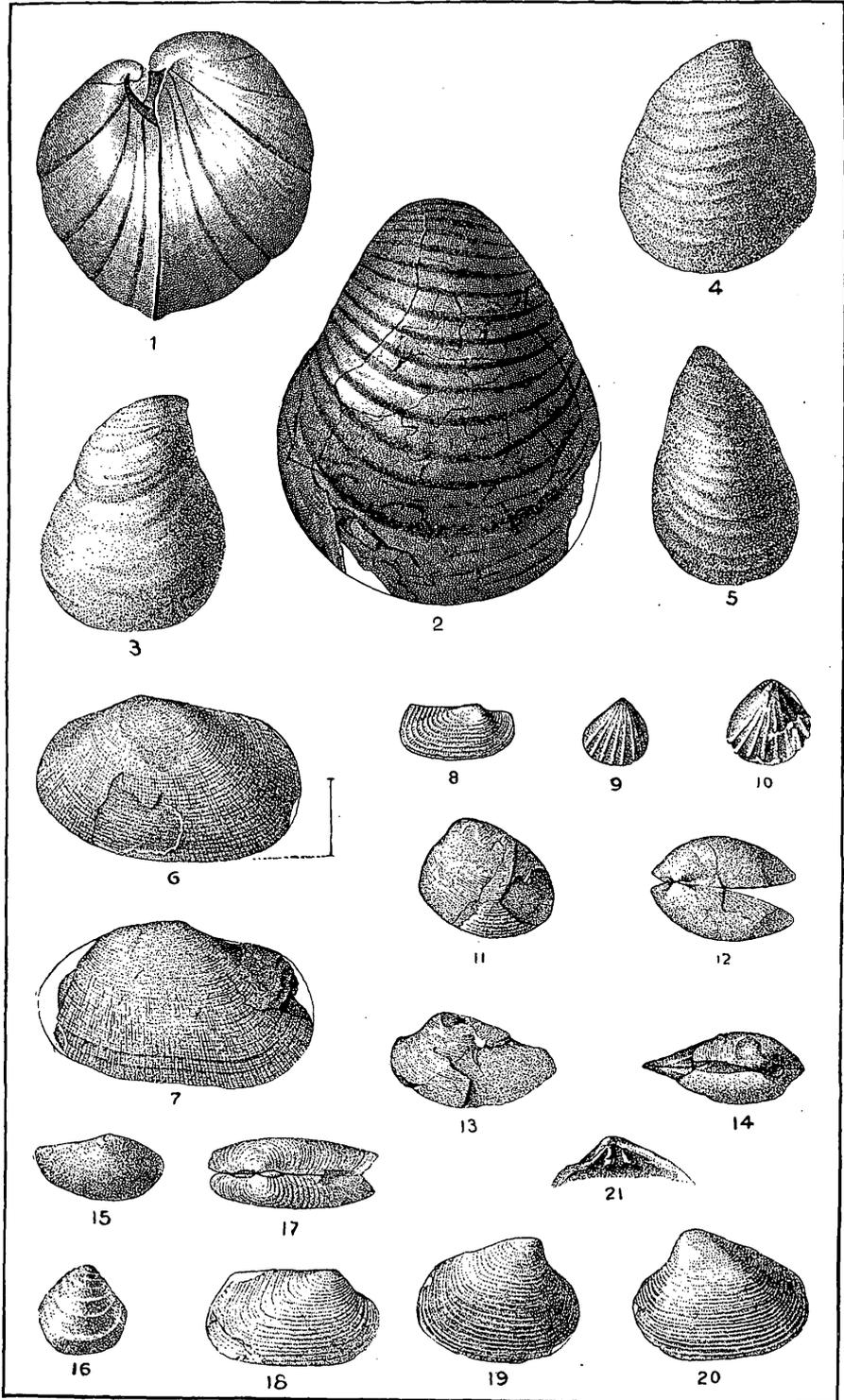


PELECYPODA: AVICULIDÆ.

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PLATE VI.

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Unless otherwise stated the figures are natural size.	

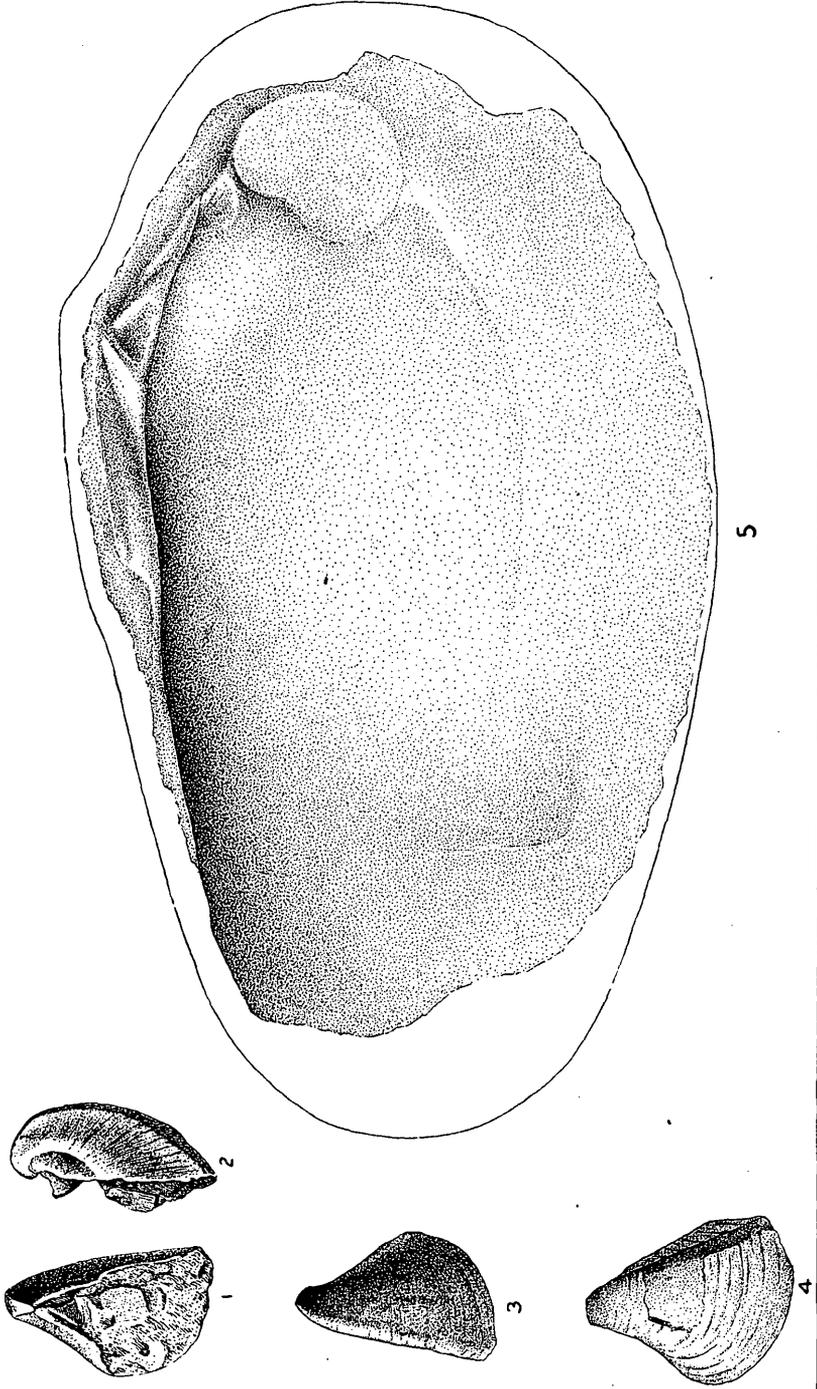


PELECYPODA: AVICULIDÆ, ARCIDÆ, NUCULIDÆ, AND ASTARTIDÆ.

PLATE VII.

PLATE VII.

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(See Pls. VIII, IX, and X.)	
All figures natural size.	



PELECYPODA : ASTARTIDÆ AND CARDINIIDÆ.

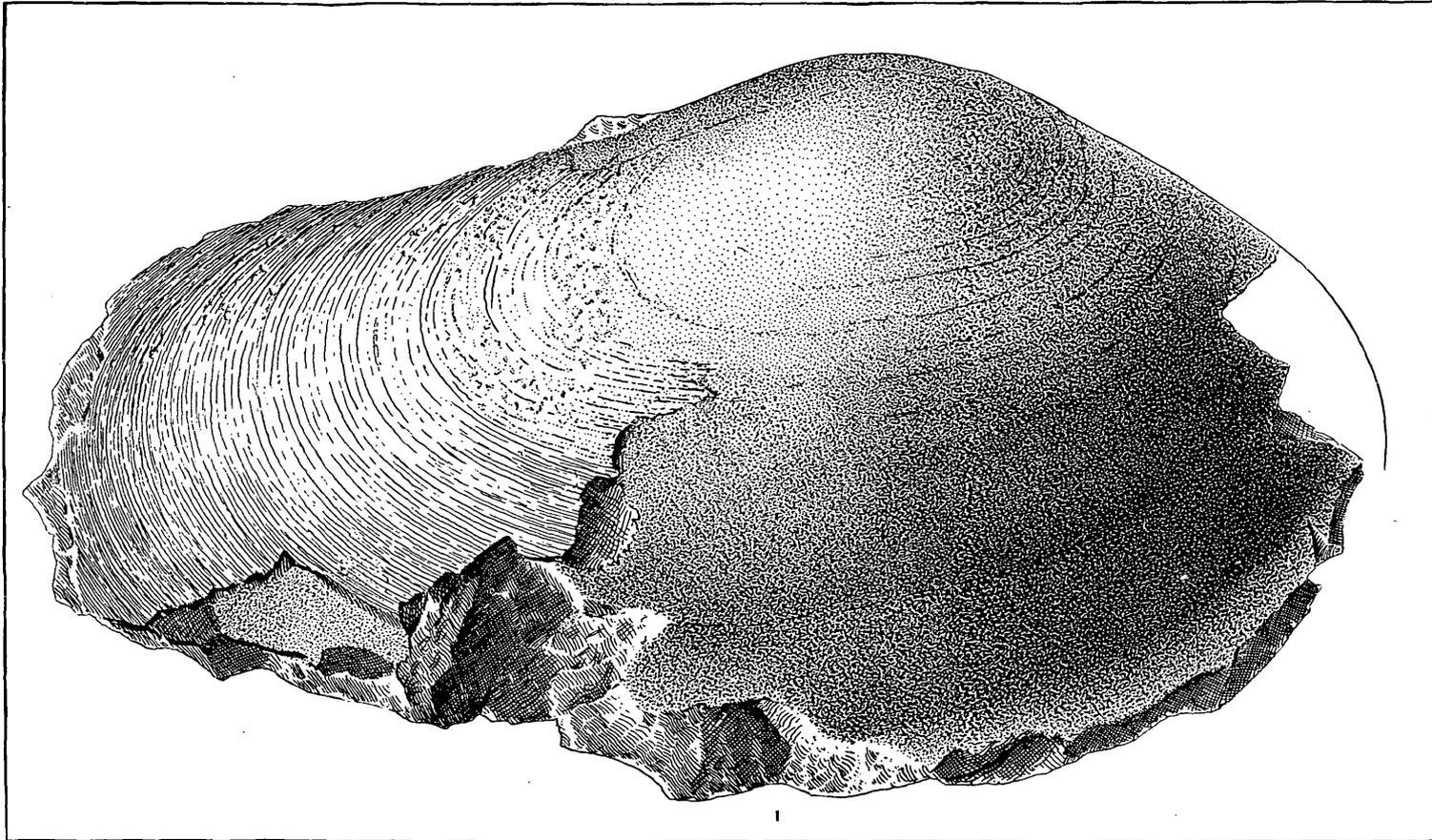
PLATE VIII.

PLATE VIII.

CARDINIOPSIS UNIOIDES n. sp.

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Fig. 1. Right valve of a large specimen. Natural size.
(See Pls. VII, IX, and X.)

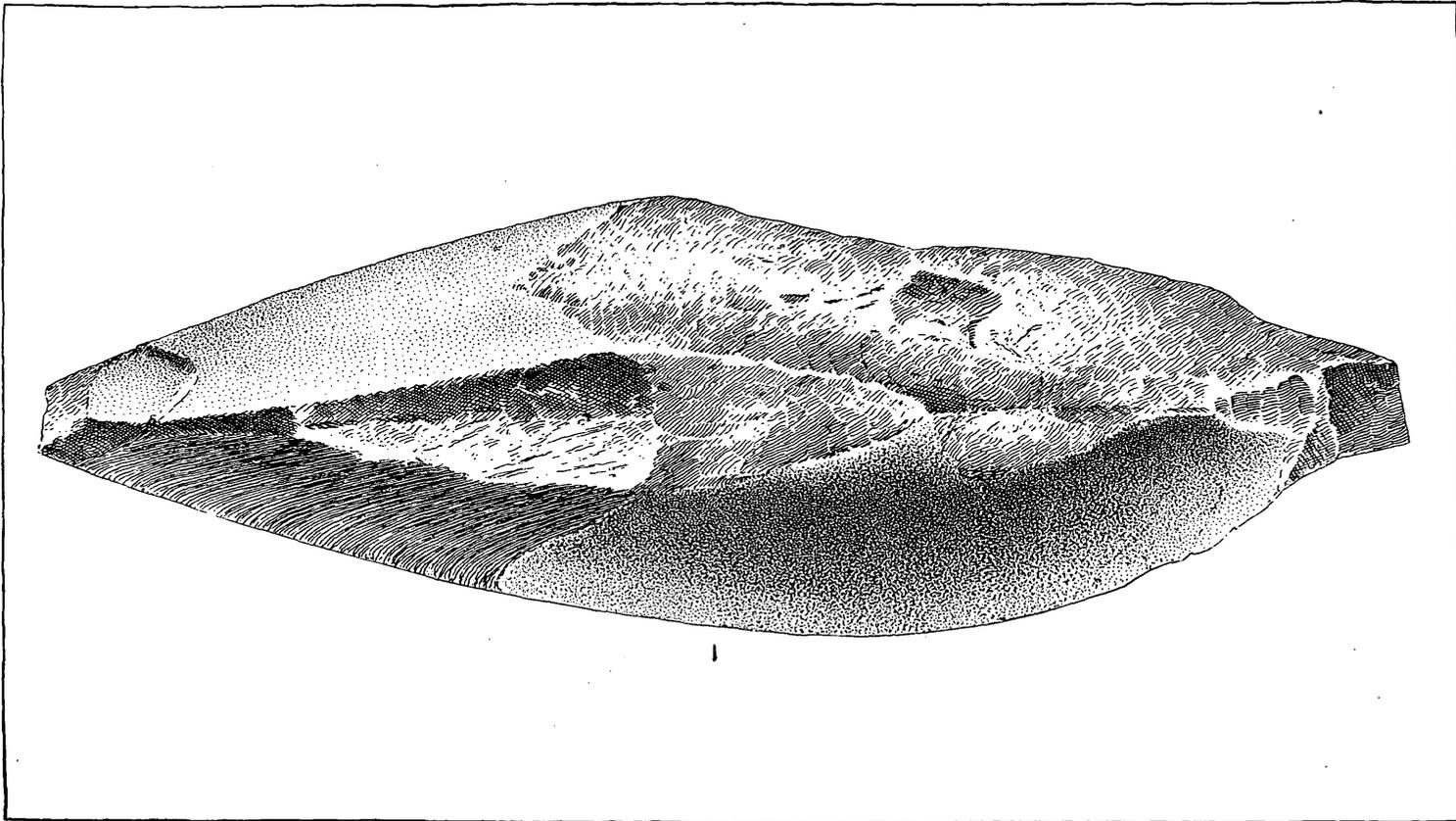


PELECYPODA: CARDINIIDÆ.

PLATE IX.

PLATE IX.

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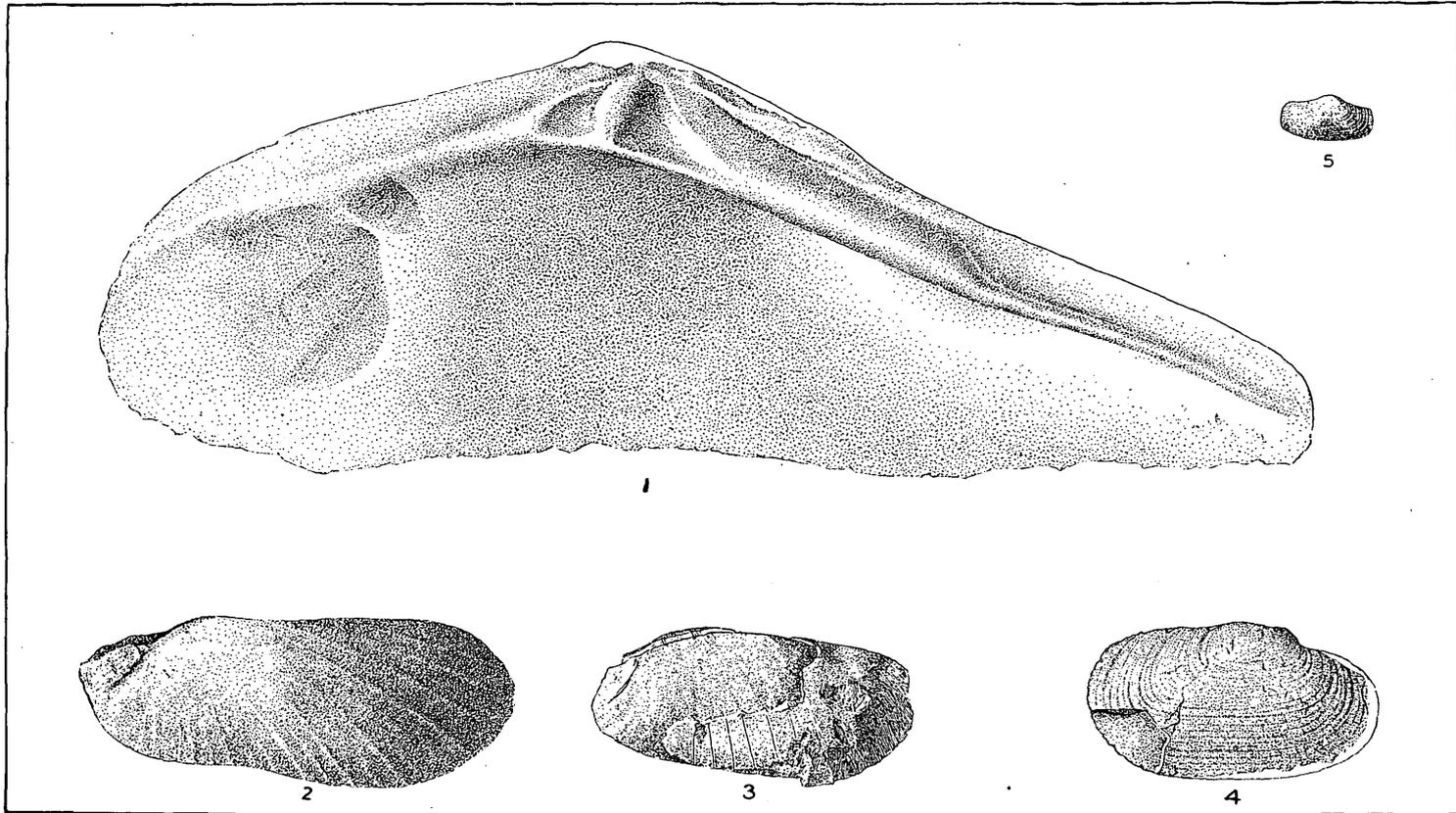


PELECYPODA: CARDINIIDÆ.

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PLATE X.

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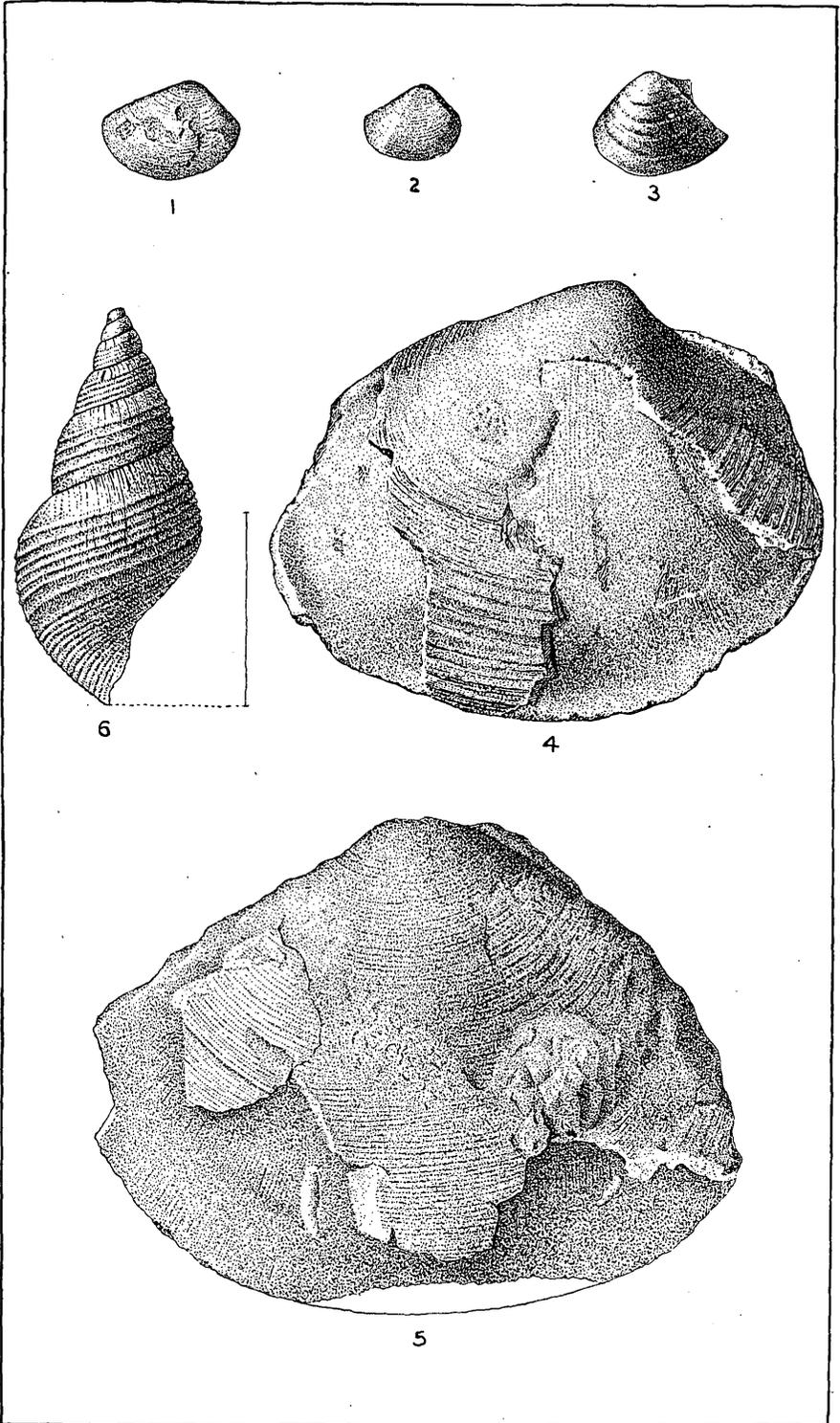
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Unless otherwise stated the figures are natural size.

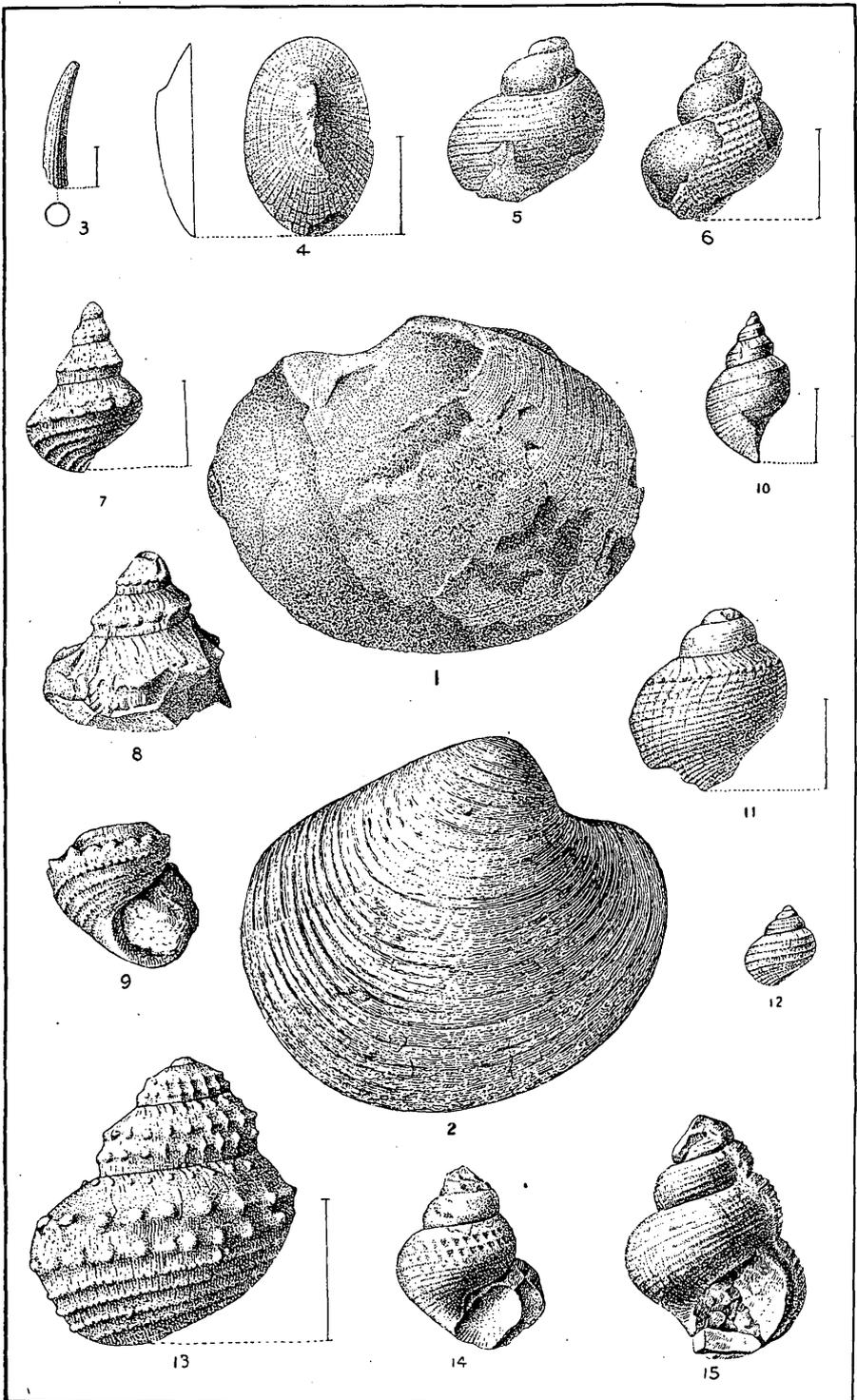


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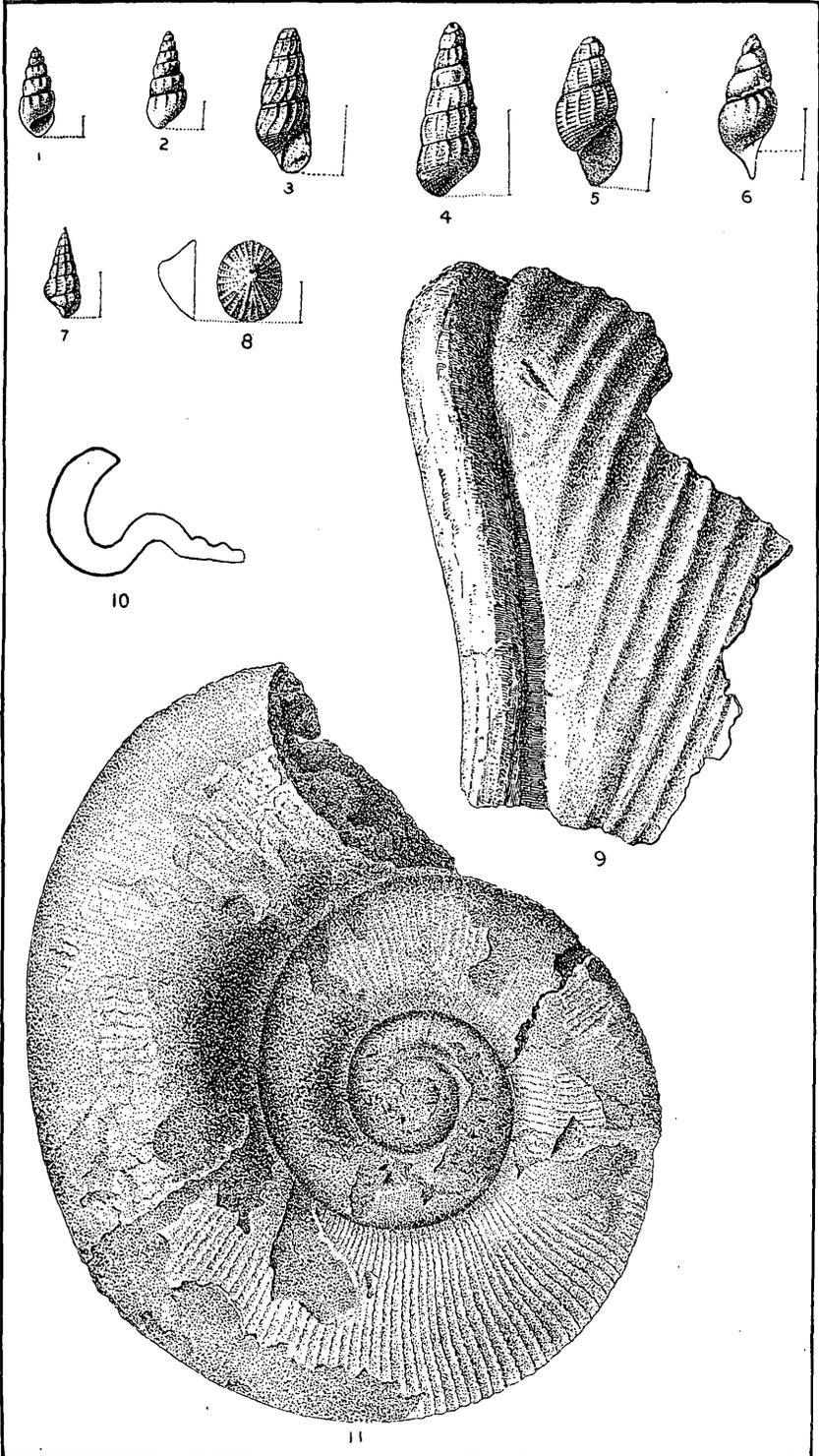
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Unless otherwise stated the figures are natural size.



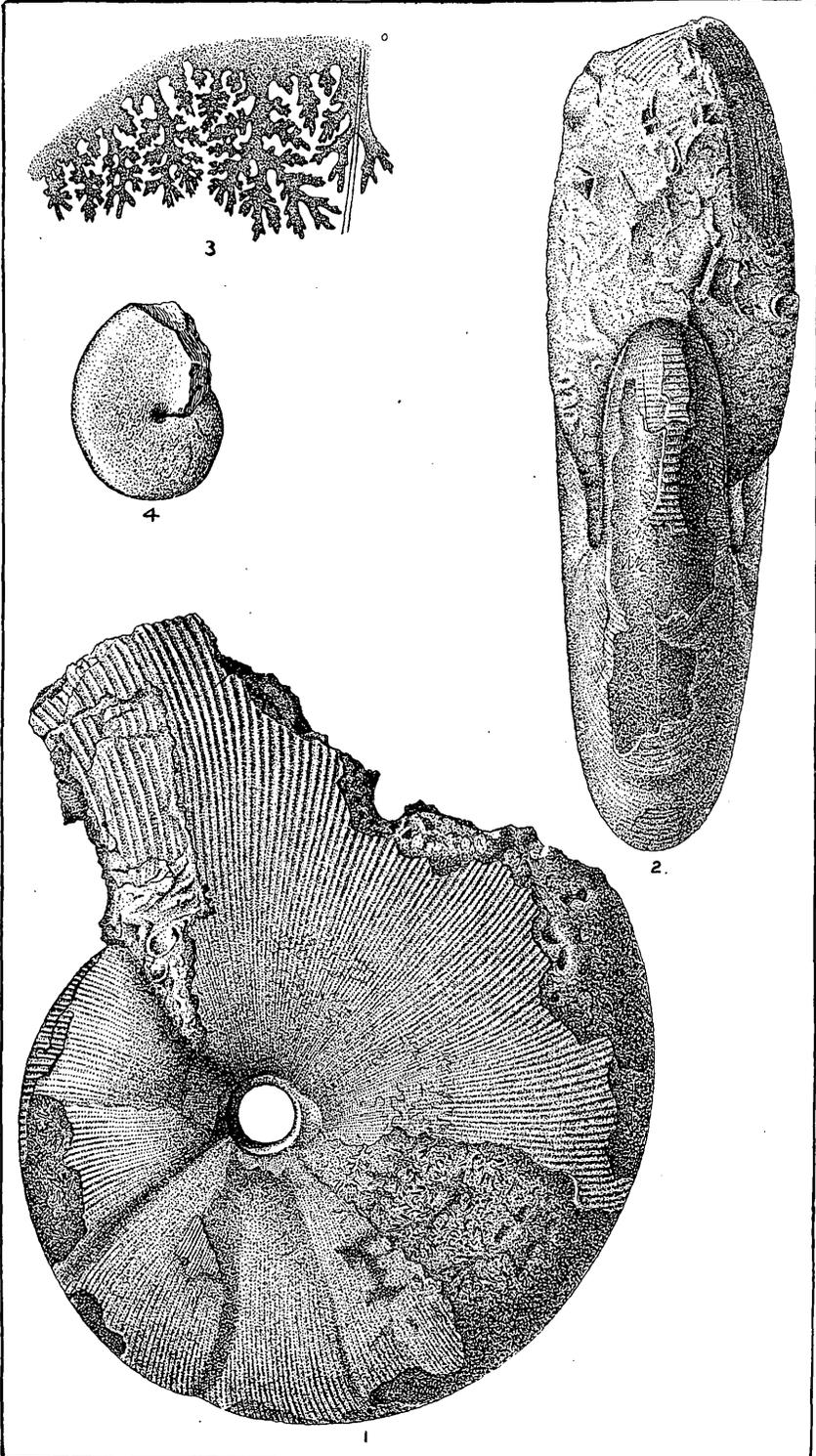
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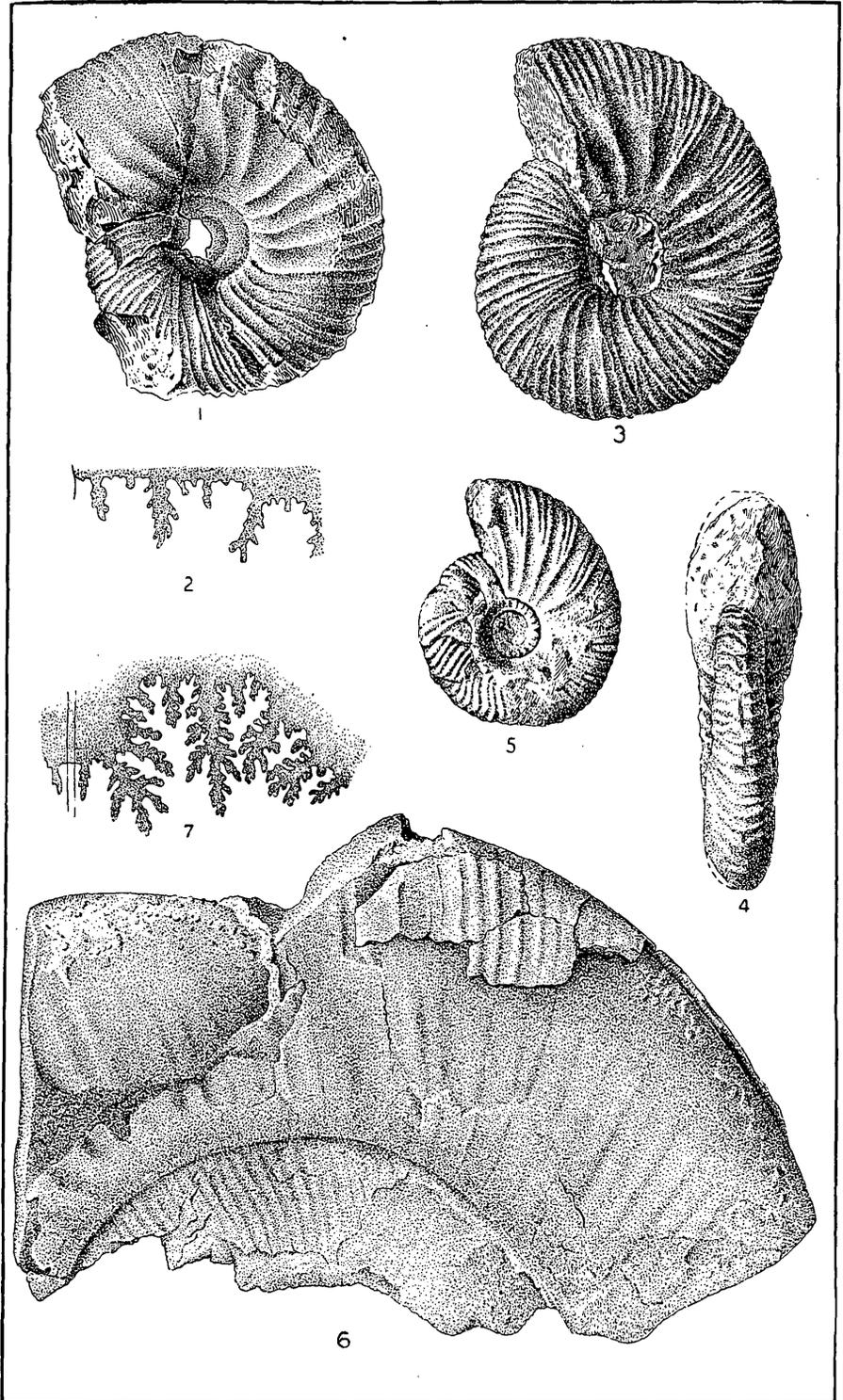
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Unless otherwise stated the figures are natural size.

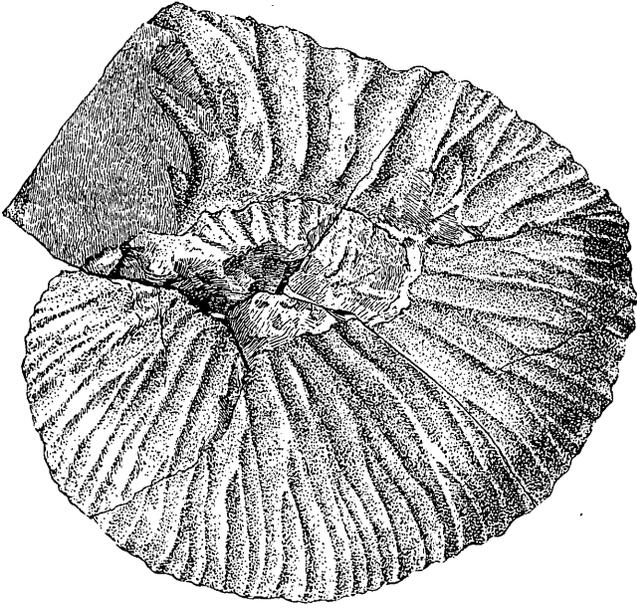


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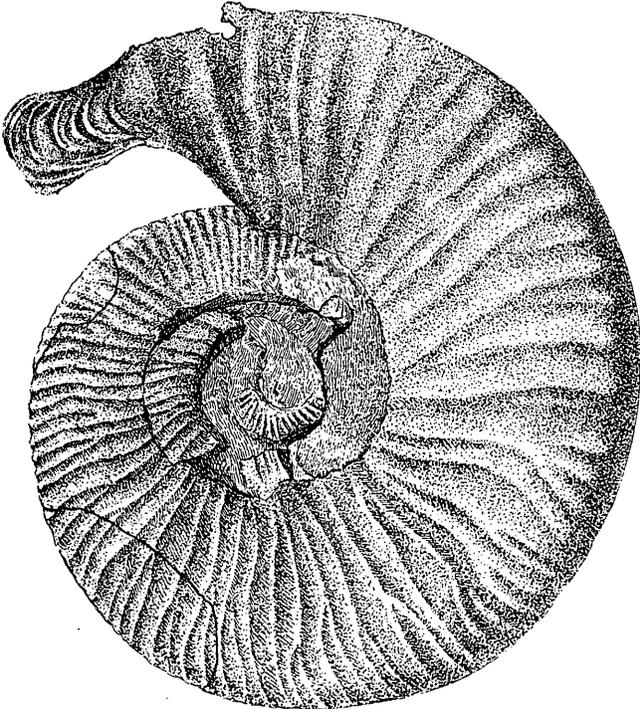
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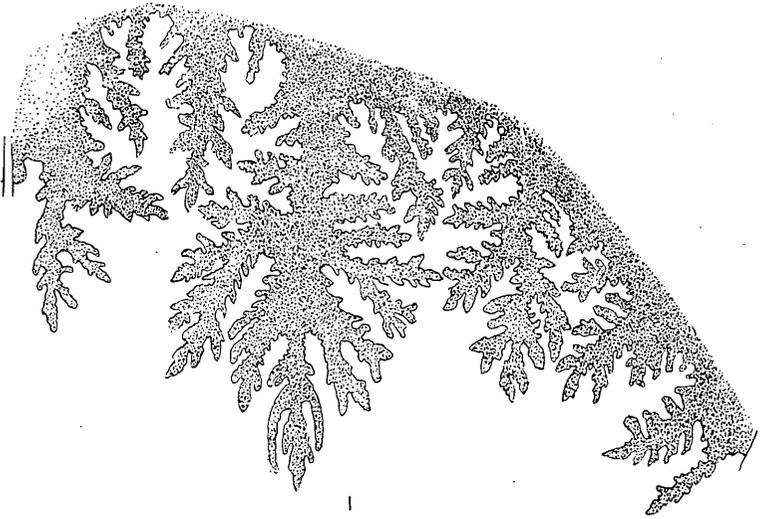
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CEPHALOPODA: OLCOSTEPHANUS AND HOPLITES.

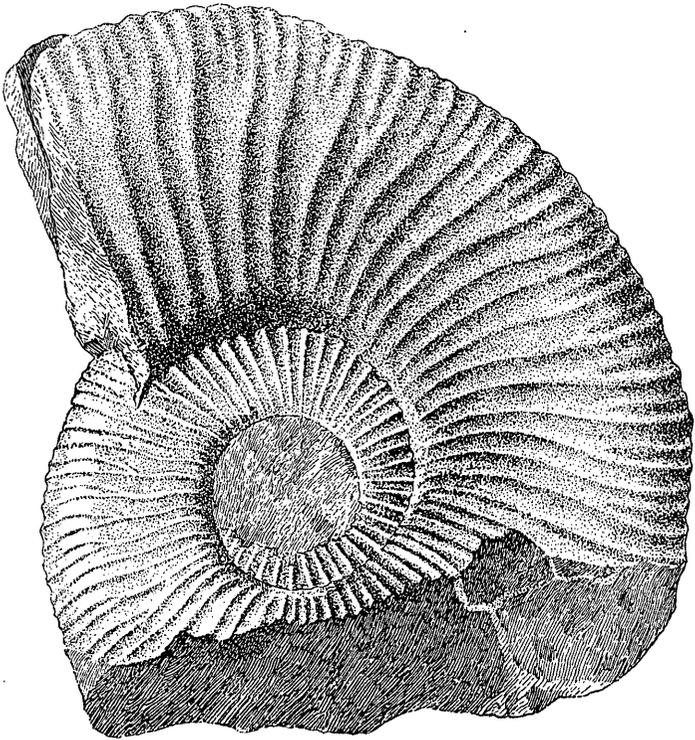
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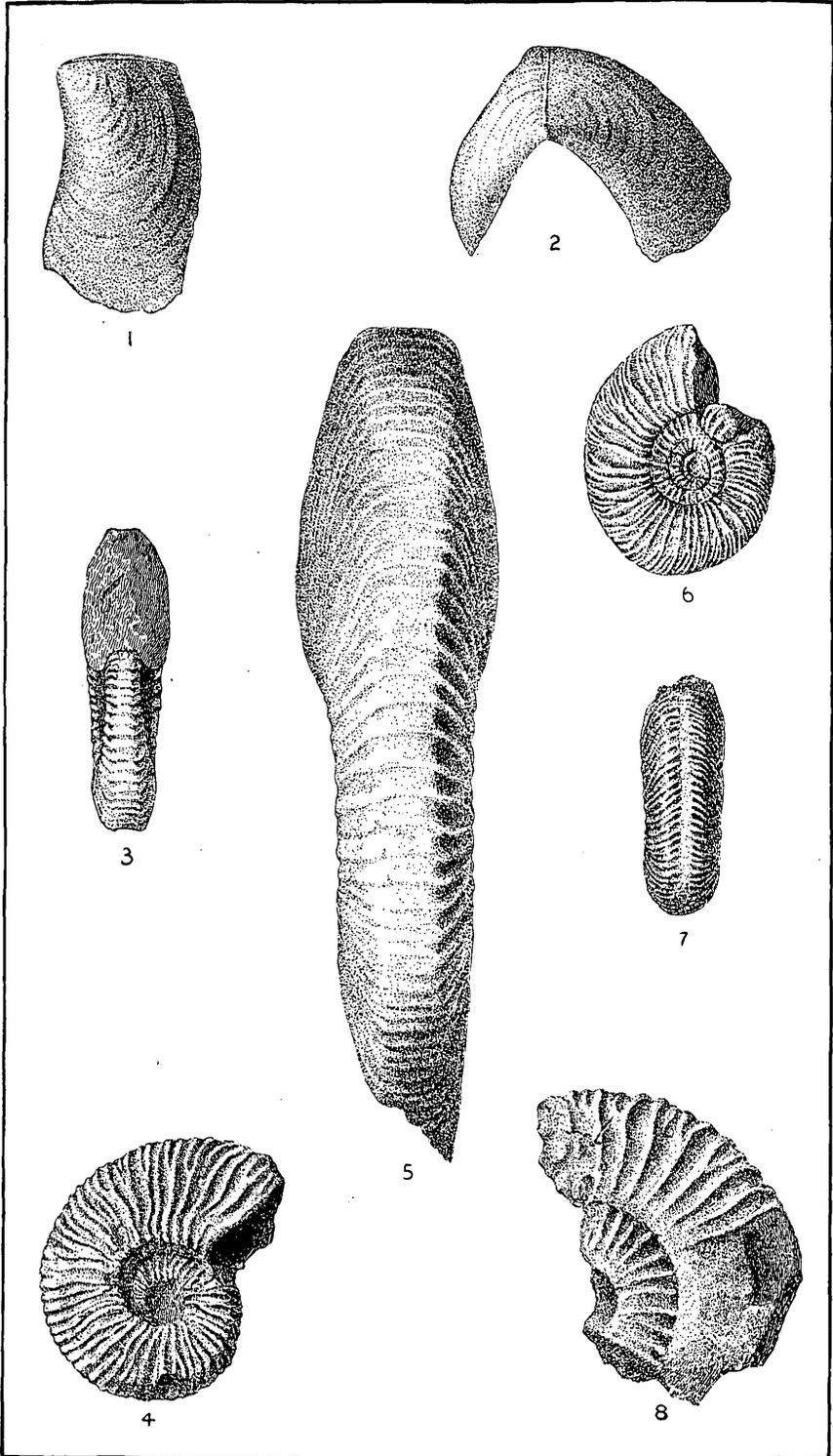


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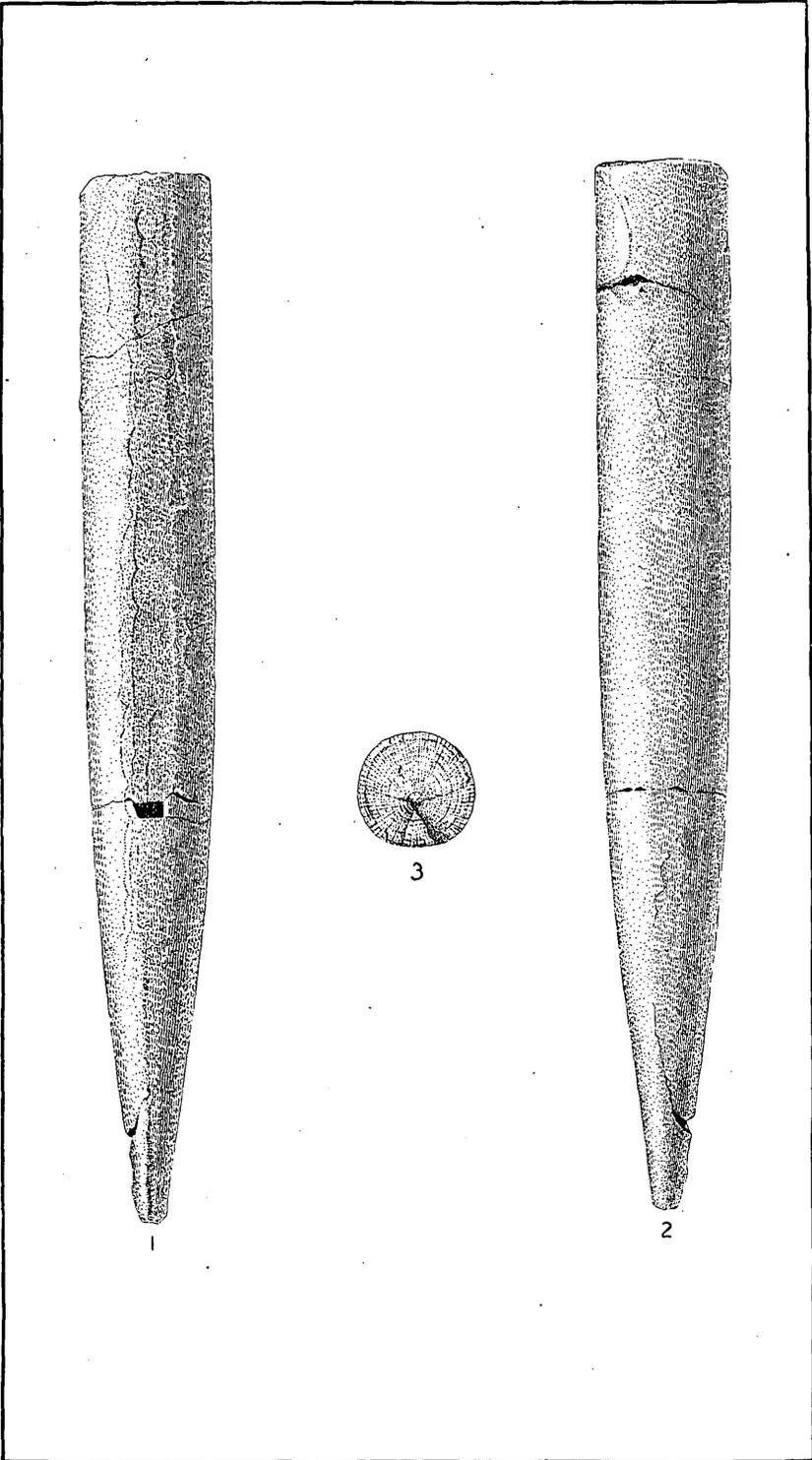
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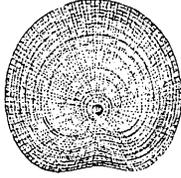
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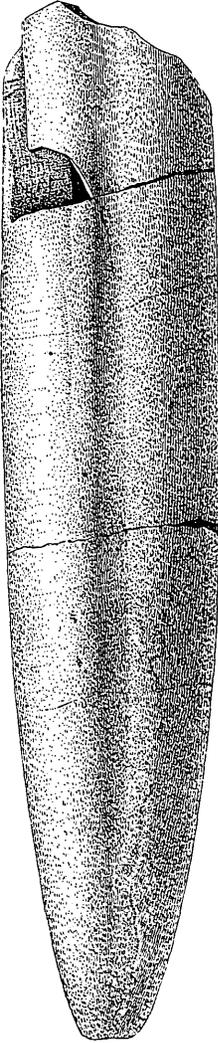
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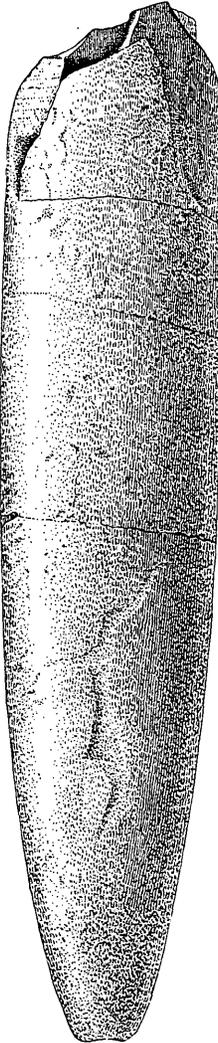
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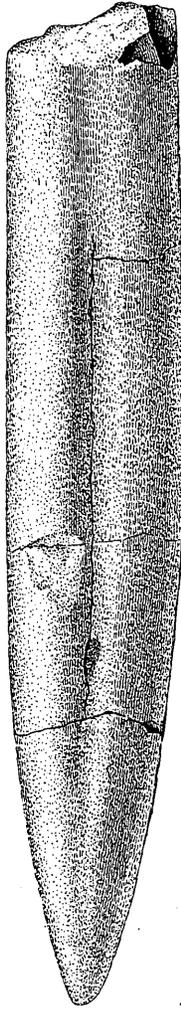
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