Molluscan Fauna of the Morrison Formation

GEOLOGICAL SURVEY PROFESSIONAL PAPER 233-B

Molluscan Fauna of the Morrison Formation

By Teng-Chien Yen

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY, 1950, PAGES 21-51

GEOLOGICAL SURVEY PROFESSIONAL PAPER 233-B

Illustrations and descriptions of pelecypods and gastropods

Summary of the stratigraphy, by John B. Reeside, Jr.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1952

UNITED STATES DEPARTMENT OF THE INTERIOR

Oscar L. Chapman, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C.—Price 65 cents (paper cover)

CONTENTS

ILLUSTRATIONS

MOLLUSCAN FAUNA OF THE MORRISON FORMATION

By Teng-Chien Yen

ABSTRACT

The Morrison fauna of Colorada, Utah, Wyoming, and Montana has yielded 17 species of pelecypods in 3 genera and 32 species of gastropods in 19 genera. All of these are fresh-water forms. One genus *(Hadrodon)* and 5 species of pelecypods, and 3 genera *(Amplovalvata, Mesauriculstra* and *Limnopsis)*, and 11 species of gastropods are described as new. Many of the genera are still living, though no species extends into even the immediately overlying beds. It is concluded that the Morrison fauna indicates a Jurassic age and that it may be pre-Purbeckian.

INTRODUCTION

The present paper embodies a systematic study of the molluscan fauna of the Morrison formation and the distribution of the fauna in Colorado, Utah, Wyoming, and Montana. It is based mainly on material collected by members of the U. S. Geological Survey supplemented by additional collections by me during a field trip to Colorado and Wyoming in the summer of 1945. All these collections are in the U. S. National Museum.

Among the invertebrates of the Morrison formation, mollusks are comparatively rich in species as well as in individuals. In general, they are well preserved in the limestone beds; however, the calcified specimens are brittle and difficult to prepare satisfactorily for study. At a few localities, the fossiliferous rocks are partly silicified, and the rich fossil content, after being etched with acid, furnishes more perfectly preserved specimens.

In summary, the molluscan fauna yields 17 species of pelecypods in 3 genera and 1 family, and 32 species of gastropods in 19 genera representing 9 families. Among them, 1 genus and 5 species of bivalves, 3 genera and 11 species and subspecies of univalves are herein described as new. The majority of the genera are still represented in the living fauna as well as in the intermediate geologic formations; but the species are entirely extinct even in the beds immediately above the Morrison formation.

ACKNOWLEDGMENTS

In completing the present study, which has been carried on at various times from 1945 to 1947, I have to express my thanks first of all to the Geological Society of America, for its financial support of my research project through grants from the Penrose Fund in 1945 and 1946. Grateful thanks are due to the authorities of the U. S. Geological Survey and the U. S. National Museum for their courtesies and kindnesses in putting their collections of material freely at my disposal; and in these institutions the main part of my research project has been carried out. I am especially indebted to Dr. John B. Reeside, Jr., who has given me much time in consultations and in critical reading of the manuscript. I am indebted also to Dr. T. W. Stanton for the privilege of including in this work a number of collections of specimens that he had partly identified, in manuscript.

During my field work in Colorado and Wyoming in the summer of 1945 I enjoyed the hospitality of and pleasant association with many friends in those States. Special thanks go to Professor Gordon Alexander, then Acting Director of the State University Museum of Natural History in Boulder, Colorado, for his kindness of providing me a working office in the Museum and transportation for a number of local trips; to Dr. J. David Love and Mr. H. A. Tourtelot of the U. S. Geological Survey for their assistance in visiting a number of localities in Wyoming; and to Mr. Vincent Evans, a resident geologist of the Carter Oil Company in Grand Junction, Colorado, who accompanied me on visits to localities near Grand Junction to collect additional fossils.

During a visit to Great Britain to examine collections of Purbeckian and the Wealden mollusks I was greatly aided by Dr. L. R. Cox, of the Department of Geology in the British Museum (Natural History), and Mr. R. V. Melville and Mr. C. P. Chatwin, of the Geological Survey of Great Britain, and I deeply appreciate their kindness and courtesy.

SUMMARY OF THE STRATIGRAPHY OF THE MORRISON FORMATION

By JOHN B. REESIDE, JR.[1]

The Morrison formation is widely distributed in the western interior of the United States. It has been recognized on the south in northern New Mexico and northeastern Arizona; on the west as far as central Utah, west-central Wyoming, and western Montana; on the north as far as the Canadian border in Montana; and on the east under the high plains of western South Dakota, western Nebraska, western Kansas, eastern Colorado, and the Oklahoma Panhandle. How much farther east it may confidently be recognized in wells is not certain, and whether it is represented in Canada in the Kootenay of that country is debated.

The deposits now designated the Morrison formation have, under various local names, been of interest to geologists since almost the beginning of geologic exploration of the West. As the "*Atlantosaurus* beds," the "Beulah clays," the "Como beds," and the "McElmo formation;" as part of the "Dakota group," the "Cascade formation," the "Beckwith formation," the "Flaming Gorge group," and the "Gunnison formation;" and under several descriptive terms reference to them has appeared many times in the literature. The remains of giant reptiles contained in them were noted early, and some of their molluscan fossils were among the earliest invertebrates to be recorded from the interior region.

The continuing interest in the Morrison formation has resulted in the accumulation of a large body of pertinent literature. Mook (1916) listed and evaluated the publications to that date. Baker, Dane, and Reeside (1936) reviewed particularly the literature for the southern Rocky Mountains and adjacent Colorado Plateau. Stokes (1944) brought up to date the record for this southern area and considered some of the more remote areas also. No recent general summary of the literature has been made.

The Morrison formation has always been a subject of controversy. A difference of opinion appeared early as to whether the Morrison deposits should be referred to a Late Jurassic or an Early Cretaceous age, and this difference has persisted into rather recent years. At the present time opinion seems to be heavily in favor of assigning the formation to the Jurassic. The current differences of opinion center mainly on the placement of the boundaries in many local sections.

The name Morrison was first published by Whitman Cross in 1894. G. H. Eldridge was apparently the original proposer, though his discussion was not actually published until 1896 (Emmons). The name was based on incomplete exposures at the town of Morrison, Colo. A paper by Waldschmidt and Leroy (1944) proposed the adoption of a complete section newly exposed in a road-cut 2 miles north of Morrison as the more practical type section.

Eldridge's original description of the formation included, in the upper part, sandstones and associated shaly beds that are now assigned to the Lower Cretaceous. Excluding these, the beds near Morrison form an acceptable standard section, particularly the complete exposure described by Waldschmidt and Leroy. In this exposure the basal unit is a sandstone 30 feet thick. This is overlain, in succession, by 55 feet of gray and red shale with charophyte oogonia, 50 feet of gray clay and limestone, 51 feet of gray shale and sandstone with dinosaurian remains, 37 feet of red shale, and 76 feet of variegated shale and sandstone. The total thickness is about 300 feet.

At other places along the eastern foothills of the Front Range in Colorado, the lowest Jurassic unit is a massive cross-bedded light-colored sandstone that is generally correlated with the Entrada sandstone, a part of the San Rafael group of Utah. Upon it rest beds of sandstone and shale, and locally gypsum, to a thickness of some tens of feet, that may be a correlative of the marine Curtis formation, also a part of the San Rafael group, though distinctive paleontologic evidence is not known along the Front Range. Next above comes about 30 feet of interbedded gray shale and limestone that yields only fresh-water fossils, chiefly calcareous algae. This unit was included by Lee (1927) in his marine Sundance formation, but seems better placed, because

[1] The writer is indebted for very helpful suggestions in compiling this discussion to W. A. Cobban, L. C. Craig, C. N. Holmes, R. W. Imlay, J. D. Love, and W. L. Stokes.

of its character and its fauna, in the Morrison formation (Reeside, 1931). The remainder of the Morrison is a unit of variegated mudstones and lenticular sandstones about 200 feet thick, upon which lie sandstones and shale of Early Cretaceous age. The area north of Canon City has yielded a notable dinosaurian fauna and, associated with it, the most extensive single assemblage of mollusks known from the Morrison formation.

In northern Mexico and northeastern Arizona the beds generally accepted as the Morrison formation show a marked change of lithologic facies from east to west. In northeastern New Mexico the Morrison formation consists of variegated mudstones and lenticular sandstones much like those of the foothills of the Front Range and about 200 feet thick. These rest on a gypsum and limestone sequence as much as 80 feet thick that is generally called the Todilto limestone and accepted as representing the Curtis interval of Utah, though older opinions placed it at both higher and lower levels (Baker et al., 1947). It has been proposed recently (Baker et al., 1947) to include the Todilto and locally associated thin-bedded sandstones in the Wanakah formation, extending the use of that name from southwestern Colorado, and to consider the Wanakah equal to the upper part of the San Rafael group. The massive sandstone beneath the Wanakah is accepted as representing the Entrada, though it has been called locally Exeter sandstone in the east and Wingate sandstone in the west. The Morrison in the east is overlain sharply by the Purgatoire formation, a marine unit of Lower Cretaceous age. Westward the Morrison formation acquires sandstones in the lower part, apparently replacing the shalier beds, and this replacement continues until, adjacent to the New Mexico-Arizona boundary, the interval is all sandstone. It has been called the Zuni sandstone by Dutton (1885) and in part erroneously referred to the much older Navajo sandstone by Gregory (1917) and others. The Zuni sandstone of Dutton reaches a maximum thickness of about 600 feet but is much less than that at many points. It is underlain by the Wanakah formation and is overlain by sandstone that has generally been considered Cretaceous and called the Dakota sandstone, though the age assignment is not well supported by paleontologic evidence.

In western Colorado and adjacent parts of Utah the Morrison formation was formerly included in the "McElmo formation" and in the "Gunnison formation," and more recently its boundaries have been the subject of discussion (Stokes, 1944). The section near Grand Junction (C. N. Holmes, unpublished data) may be taken as typical. Here greenish thin-bedded sandstones and shales about 45 feet thick rest on the Entrada sandstone and have been correlated with the Summerville formation, the highest unit of the San Rafael group of Utah. On these lies about 25 feet of gray shales and limestones that contains fresh-water fossils, and in turn interbedded lenticular sandstone and shale about 160 feet thick. The sandstone unit is generally called the Salt Wash sandstone member of the Morrison formation, but the character and fauna of the limestone unit seem to warrant inclusion of it also in the Salt Wash. The remaining uppermost part of the Morrison formation is a zone 350 feet thick made up chiefly of variegated mudstone and now called the Brushy Basin shale member (Gregory, 1938). Upon the Brushy Basin member lie sandstones and shales now designated the Burro Canyon formation (Stokes, 1948) and assigned to the Lower Cretaceous. A section measured 20 miles farther west, near the Utah-Colorado boundary (C. N. Holmes, unpublished data), shows little or no limestone resting on the Summerville formation, the Salt Wash member 250 feet thick, and the Brushy Basin member 280 feet thick.

The correlation of the units between the sandy deposits of the Salt Wash member of the Morrison and the Entrada sandstone is in some dispute, because they vary in composition from place to place, at some places including thick-bedded gypsum and at others thick, massive sandstone. In this varied part of the section a number of formation and member names have been applied locally. In Colorado such names as Pony Express limestone and Wanakah marl (Burbank, 1930) and Bilk Creek sandstone and Junction Creek sandstone (Goldman, 1941) have been proposed. The first three may represent equivalents of the upper units of the marine San Rafael group of central Utah and the Junction Creek sandstone may belong to the Morrison formation. Similar heterogeneous units underlying the Brushy Basin member in southeastern Utah have been named by Gregory (1938) the Bluff sandstone member, Recapture shale member, and Westwater Canyon sandstone member. The Bluff sandstone member has been correlated with the Entrada sandstone by some geologists, with a later part of the San Rafael group by others, and with post-San Rafael deposits by others. The Recapture and Westwater Canyon members are generally accepted as parts of the Morrison and as the lateral equivalent of the Salt Wash member and part of the Brushy Basin member.

In central Utah (Gilluly, 1928; Baker, 1946) a marine Jurassic sequence (the San Rafael group) has been recognized, the highest unit being the Summerville formation and below it in descending order the Curtis formation, the Entrada sandstone, and the Carmel formation. Above the Summerville formation lies the rather heterogeneous Morrison formation, with a unit of sandstone and shale, the Salt Wash sandstone member, about 200 feet thick, in the lower part, and a dominantly variegated mudstone unit, the Brushy Basin shale member, about 300 feet thick, above it. The overlying beds below the Dakota sandstone are several hundred feet thick, are very similar to the Brushy Basin member, though locally containing notable conglomerates, and have been included by earlier writers in the Morrison formation. Stokes (1944) has proposed considering them Early Cretaceous in age and has divided them into the Buckhorn conglomerate below (a discontinuous unit) and the Cedar Mountain shale above. The boundary of the Cedar Mountain shale of Stokes and from his Brushy Basin shale at places where there is no conglomerate is difficult to establish though Stokes (letter of June 19, 1950) reports that microfossils identified by R. E. Peck assure the assignment of the Cedar Mountain to the Lower Cretaceous.

Along the south flank of the Uinta Mountains in northern Utah the beds assigned to the Morrison formation include in the east about 700 feet of variegated mudstones with lenticular sandstones and conglomerates that rest upon the marine Curtis formation. Westward the Morrison is said to be 1,500 or more feet thick. These beds have yielded a varied dinosaur fauna that assures correlation of the unit with the typical Morrison formation. Upon the Morrison lie conglomerates and shales that are commonly assigned to the Lower Cretaceous and included under the designation "Dakota(?) sandstone" (Huddle, 1947). Though paleontologic evidence is lacking, this assignment seems reasonable.

In southwestern Wyoming and the adjacent parts of Utah and Idaho the name Morrison has not been used, but an equivalent of the Morrison formation was most probably included locally in the Beckwith formation (Veatch, 1907). Where the Beckwith has been divided (Mansfield, 1927), as in central western Wyoming and adjacent parts of Idaho, the Ephraim conglomerate, basal formation of the Gannett group, must contain any equivalent of the Morrison formation present, for it is underlain by the marine Jurassic Stump formation (equivalent to the Curtis formation faunally) and is overlain by the Peterson limestone, which contains a Lower Cretaceous nonmarine fauna. No paleontologic evidence has been presented that the Ephraim actually contains Jurassic beds, and it is usually assigned to the Lower Cretaceous, thus following the original assignment, though Stokes (1944) has tentatively identified a lithologic equivalent of the Morrison formation in it.

In west-central Wyoming the beds assigned to the Morrison formation are dominantly a variegated mudstone, though locally the whole zone is massive sandstone. The thickness in the Wind River Basin ranges from 125 to 175 feet (Love, 1945, 1947). Both boundaries are somewhat arbitrary. At localities where the lower part of the Morrison is sandstone, the separation of the marine Sundance formation from the Morrison is based largely on the presence of glauconite in the widespread uppermost sandstones of the Sundance and the absence of it from the Morrison. The Cloverly formation, above the Morrison, is generally composed of a basal chert conglomerate, a middle part of variegated mudstones containing some lenticular sandstones and conglomerates, and an upper sandy unit, commonly containing ferruginous material and weathering "rusty." Where the basal conglomerate is lacking, distinguishing the variegated beds of the Morrison from the similar beds of the Cloverly must be on minor lithologic characteristics and is a difficult task.

A series of beds totalling 370 feet in thickness, near the northwest end of the Wind River Range, was ascribed by Richmond (1945) to the Morrison formation and said to rest directly upon the Sundance. These beds include a basal conglomeratic sandstone, red and gray mudstones, sandstones, and shales totaling 135 feet in thickness, upon which rest a limestone 10 feet thick, a shale 20 feet thick, and another limestone 5 feet thick, and then variegated shales 200 feet thick. The next overlying deposits are "rusty beds" 240 feet thick, ascribed to the Cloverly formation. The 10-foot limestone has yielded a varied fauna of nonmarine mollusks identified by Yen and Reeside (1946) as a Jurassic fauna of Morrison age. The molluscan fauna has no species in common with any of the known Lower Cretaceous faunas, but it does contain four species that elsewhere are known only from Morrison horizons. R. E. Peck (J. D. Love, letter of January 5, 1951) has identified, from presumably the same limestone, charophyte oogonia and ostracodes belonging to a widespread assemblage of Early Cretaceous age. If the identification of the horizon is valid, the interpretation of the age of the beds is left in doubt. Pending further investigation, the Morrison is here construed as including at least the beds up to the base of the 200-foot variegated shale unit.

In the Bighorn Basin, north-central Wyoming, the Morison formation is stated to be about 200 feet thick in the southern part of the Basin and 500 feet or more thick in the northern part, though certainly some part of this greater thickness represents beds that are elsewhere assigned to the Lower Cretaceous Cloverly formation (Lee, 1927; Pierce, 1941). The formation is composed of sandstones and variegated shales.

In eastern Wyoming and adjacent South Dakota, particularly around the Black Hills, the Morrison formation is said to be about 200 feet thick at its maximum and to consist of variegated mudstones, fresh-water limestones, and minor sandstones (Darton, 1925). Beneath it at some localities lies a cross-bedded sandstone, the Unkpapa sandstone, also about 200 feet thick at its maximum. As each formation at its locality of maximum thickness appears to displace the other completely, it is likely that they are contemporaneous facies. Both locally rest on the marine Jurassic Sundance formation and both locally are overlain by the Lower Cretaceous Lakota sandstone. The Morrison in the Black Hills region has yielded characteristic dinosaurs and invertebrates.

In southern Montana the Morrison includes variegated mudstones, minor zones of sandstone, and at the top a widespread zone of carbonaceous shale and thin coal beds. The formation is said to range up to 400 feet in thickness but is apparently about 250 feet thick on the average (Thom, 1935; Hadley, 1945; Gardner, 1945). It rests upon the marine Jurassic deposits with apparent conformity and is overlain by the Lower Cretaceous Cloverly (or Kootenai) formation. In central and northwestern Montana the lower part of a sequence of greenish-gray clay shale and limestone up to several hundred feet thick, with sandstone and locally a commercial coal bed at the top, was tentatively referred by earlier writers (Calvert, 1909; Fisher, 1909) to the Morrison formation. By some later writers it was included in the Lower Cretaceous Kootenai formation, but in recent years it has again been placed in the Morrison formation because of its composition and structural relations (Cobban, 1945) and of its flora and fauna (Brown, 1946). The Kootenai formation unconformably overlies the Morrison and differs from it in fossil content and lithologic character. The Morrison rests upon the marine Jurassic deposits with no indication of any sort of hiatus.

In general the beds that include the change from the marine Jurassic deposits to the nonmarine Morrison formation provide little physical evidence of interruption of sedimentation. There is no basal conglomerate and no sharp change in lithologic character. On the contrary, over large areas there is so little change in composition of the rocks that the basal boundary of the Morrison must be more or less arbitrarily selected. Nor does the paleontologic evidence appear to indicate a considerable gap, though, because of the shift from marine deposition represented by the underlying beds to nonmarine deposition represented by the Morrison formation, it is not easy to evaluate the data involved. The latest marine deposits preceding the Morrison are everywhere of essentially the same age, Oxfordian of the European standard sequence (Imlay, 1947), and some evidence is available that the Morrison vertebrates are of Kimmeridgian and possibly early Portlandian age (Baker, 1936). Yen indicates (pp. 34-35) that the mollusks of the Morrison suggest a greater age than Purbeckian, i. e., Portlandian or older. It would seem that such interpretations as the fossils permit do not favor the inference of a substantial break in the sequence and that the total evidence, physical and organic, implies little or no interruption in sedimentation during the change from marine to nonmarine deposition.

The beds that include the transition from the Morrison formation to the overlying Lower Cretaceous deposits, though at some places difficult to divide, indicate nevertheless at other places a physical boundary that is well defined. Where such units as the brown basal conglomeratic sandstone of the Cloverly formation, the Lakota sandstone, and the basal part of the Kootenai formation are present, the boundary is sharply marked. If the Morrison, on the basis of its dinosaurian fauna and invertebrates, be accepted as Portlandian or older, there is still unrepresented the highest Jurassic, the Purbeckian. The Gannett group of western Wyoming, the Cloverly formation of central Wyoming, and the Kootenai formation of Montana all contain the same Lower Cretaceous nonmarine mollusks, and the faunal assemblage is specifically distinct from that of the Morrison.

It is not possible to correlate these invertebrates directly with faunas outside North America, but such correlations have been made on the basis of the fossil plants associated with the mollusks. Berry (1929) regarded the lower part of the Blairmore formation of Canada as Aptian or Albian of the European standard sequence, i e., later Early Cretaceous, and also as equivalent to part of the Lakota sandstone and the Fuson shale of Wyoming. The lower part of the Blairmore contains the same molluscan fauna as the Cloverly, Gannett, and Kootenai. He regarded the Kootenay[1] of Canada, which unconformably underlies the Blairmore, as of Barremian age, i. e., somewhat earlier Early Cretaceous. Bell (1946) regarded the lower part of the Blairmore as Aptian and the Kootenay as extending perhaps from earlier Early Cretaceous to Barremian and certainly of Early Cretaceous age. Brown (1946), on the other hand, regarded the Canadian Kootenay as Jurassic, older than the Kootenai of Montana, and as equivalent to the Morrison. Whatever may be the ultimate assignment of the Canadian Kootenay, in the United States there is reason to infer a time interval between the Morrison formation and the succeeding beds that represents possibly part of the Portlandian, probably the Purbeckian, the Berriasian, the Valanginian, the Hauterivian, and possibly the Barremian of the standard European sequence.

REVIEW OF LITERATURE

The literature on the molluscan fauna of the Morrison formation has been reviewed briefly (Yen and Reeside, 1946) but, because lack of space precluded an adequate treatment in that paper, a fuller account is offered here.

Early in 1858, Meek and Hayden described *Unio nucalis* from the "southwest base of Black Hills, in lower part of no. 1," which was considered to be the lowest unit of their Cretaceous system, described in the stratigraphic part of their paper. They also mentioned that in the same matrix occur several specimens of small *Planorbis* and other univalves like *Paludina*.

In 1860, the same authors recorded *Valvata scabrida*, and *Planorbis veternus* as *nomina nuda*, and without giving a locality, but provisionally assigning them to the Jurassic. In 1861, they described fully *Neritella nebrascensis* and *Melania (Potodoma) veterna* from "head of Wind River, from a bed apparently holding a position at the base of the Cretaceous."

In 1865, Meek and Hayden fully described and illustrated the above five species, and in addition *Viviparus gilli*, apparently also from the "head of Wind River." This group of fresh-water molluscan species constitutes the earliest record attributed to the Upper Jurassic beds of North America, the Morrison formation of later years.

Further investigation in the field and additional collections of specimens, made during the last three quarters of a century, permit the following clarification of these early records:

First, the six species that Meek and Hayden described were obtained at two localities from rocks of different ages. *Unio nucalis, Valvata scabrida*, and *Planorbis veternus*, from the "southwest base of the Black Hills," are considered to be of Morrison age. *Neritella nebrascensis, Viviparus gilli* and *Lioplacodes veternus*, from "head of Wind River," have not been found in the Morrison formation exposed elsewhere in the Rocky Mountain States, though they have been repeatedly recorded in the Cloverly formation or its quivalents, and are considered to be of Early Cretaceous age.

Second, "other univalves like *Paludina*" were mentioned by Meek and Hayden in 1858, but they were never described, and they are not to be confused with *Viviparus gilli*, which the authors in 1865 described from "head of Wind River." What these *Paludina*-like snails actually were is unknown; possibly they were *Amnicola gilloides* Yen and Reeside, which has been recently recorded from the Morrison formation near Lower Green River Lakes, Mayoworth, and Freeze-out Hills, Wyoming.

Third, *Valvata scabrida*, whose position is discussed fully on page 29, has been incorrectly cited in records by later authors under different specific names. The distribution of this species seems to be restricted to the beds exposed in the Black Hills, at Mayoworth and Como Bluff, and in the Freeze-out Hills, Wyoming, and in the Grand Junction area, Colorado.

Fourth, *Planorbis veternus* seems to be a widely distributed species in the Morrison formation, much as some species of the Planorbidae are in the Recent fauna. Possibly, this species may be employed as an indicator of the Morrison formation, as it has not so far been recorded from beds either above or below that formation.

In 1878, C. A. White described *Unio stewardi* from Jurassic strata exposed near the bank of Green River in Wyoming.

The classic work on fresh-water mollusks of the

[1] The preferred Canadian form of the name.

North American Jurassic did not appear until 1886, when C. A. White published his paper on a collection from the "Atlantosaurus beds" exposed 8 miles north of Canon City, Colorado, to which he added notes on the previously described species. The fossils from Canon City are well silicified, and this work is the first paper on Morrison mollusks based on a collection of well-preserved specimens from an authentic locality. The following species were described or recorded by White (they are listed in their original nomenclature):

Unio felchi White
Unio toxonotus White
Unio iridoides White
Unio lapilloides White
Unio stewardi White
Unio macropisthus White
Valvata scabrida Meek and Hayden?
Limnaea ativuncula White
Limnaea consortis White
Limnaea? accelerata White
Planorbis veternus Meek and Hayden?

In the same paper White recorded *Unio nucalis* Meek and Hayden and *Vorticifex stearnsii* White from the "Atlantosaurus beds" exposed at Como, Wyoming, and noted the earlier reference to the Jurassic of *Viviparus gilli* Meek and Hayden, *Lioplacodes veternus* Meek and Hayden, and *Neritina nebrascensis* Meek and Hayden.

In 1900, W. N. Logan described from the Freeze-Out Hills in Wyoming:

Unio willistoni Logan
Unio knighti Logan
Unio baileyi Logan
Planorbis veternus Meek and Hayden
Valvata leei Logan

The inadequate descriptions and illustrations of the new species make these records of little help to later investigators, though unquestionably the names are fully valid. Further information and additional specimens from the nearby area now permit revision of these species in the systematic part of this work.

In 1915, W. I. Robinson described from the "Painted Desert beds" of east-central Arizona:

Valvata gregorii Robinson
Limnaea hopii Robinson

The type material is not available for the present study. The "Painted Desert beds" are not Morrison (Jurassic) but Chinle (Triassic), so that the above species will not be included in the present study.

In 1935, C. C. Branson described an interesting collection of mollusks from beds of the Morrison exposed south of Mayoworth, Wyoming. The following forms (given in their original nomenclature) were recorded or described:

Vetulonaia whitei Branson
Vetulonaia mayoworthensis Branson
Vetulonaia nucalis (Meek and Hayden)
Valvata scabrida Meek and Hayden
Valvata? jurassica Branson
Lioplacodes veternus Meek and Hayden?
Viviparus gilli Meek and Hayden
Planorbis veternus Meek and Hayden
Pentagoniostoma jurassicum Branson
Pentagoniostoma altispiratum Branson

Most of Branson's names are useful, but to distinguish his *Pentagoniostoma* from *Tropidina* H. and A. Adams on morphological grounds, is almost impossible and the two species included in his new genus, judged by his descriptions and illustrations, are most probably not congeneric. *Lioplacodes veternus* of Branson may represent an imperfect specimen of *Lymnaea ativuncula* White; his *Viviparus gilli* may be related to *Amnicola gilloides* and its small size and few whorls differentiate it sufficiently from *V. gilli;* and his record of *Valvata scabrida* was based on specimens which "agree with specimens of White," and which then should be identical with *Amplovalvata morrisonensis.* Branson gave neither figure, nor measurements for this form, so that his record must remain uncertain.

In 1942, E. L. Holt described *Vetulonaia faberi* from an exposure in Ladder Canyon, about six miles south of Grand Junction, Colorado. The species is said to occur in association with *Vorticifex stearnsii* White. In the same paper Holt mentions the presence of *Valvata scabrida* Meek and Hayden in a limestone bed exposed about one mile west of the golf course in Fruita, Colorado.

The present author obtained additional specimens from Holt's locality in 1945 enabling him to conclude that *Vorticifex stearnsii* of Holt is the adult form of *Amplovalvata scabrida* Meek and Hayden, and his *Valvata scabrida* is *Viviparus reesidei.*

In 1946, Yen and Reeside described a collection of silicified mollusks from a locality west of Mill Creek below Lower Green River Lake, on the west slope of the Wind River Mountains in the western part of Wyoming. The faunule consists of the following species:

Valvata minuscula Yen and Reeside
Amnicola gilloides Yen and Reeside
Mesocochliopa assiminoides Yen and Reeside
Mesopyrgium pendilabium Yen and Reeside
Tortacella aff. *T. haldemani* (White)
Galba ativuncula (White)
Gyraulus veternus (Meek and Hayden)
Graptophysa spiralis Yen and Reeside
Physa micra Yen and Reeside
Physa conispira Yen and Reeside

Aplexa militaria Yen and Reeside
Aplexa morrisonana Yen and Reeside
Unio iridoides White

This fauna is notable as the sole known occurrence of eight species and as the only one ascribed to the Jurassic that includes the genus *Tortacella (=Zaptychius),* previously recorded only in the Cretaceous. It has four species in common with other Morrison faunas and none with the Cretaceous. L. D. Love reports (Letter of Jan. 5, 1951) that R. E. Peck has found at this locality charophyte oogonia and an ostracode of Early cretaceous age, though the writer believes the molluscan fauna assignable only to the Morrison.

DISTRIBUTION OF THE FOSSILS

The localities from which fossils have been examined in the couse of study are shown in figure 1. These localities are as follows:

1. Lt. 38° 31′; Long. 104° 52′, Garden Park, Colorado Springs quadrangle, Colorado; collected by G. K. Gilbert, 1893; U.S.G.S. Mes. loc. 1325. The fossils are imbedded in fine-grained silty greenish-gray limestone, and the molluscan shells are replaced partly by silica and partly by calcite.

2. West side of Penitentiary Ridge, 2 miles north of Canon City, Fremont County, Colorado; collected by C. E. Siebenthal, 1904; U.S.G.S. Mes. loc. 3211. The matrix is dark-grayish limestone and the shells are calcified.

3. Near Canon City, Fremont County, Colorado; collected by M. P. Felch, 1885; U.S.G.S. Mes. loc. 481. The matrix is in part coarse-grained limestone of grayish color and in part pale-reddish sandstone. The fossils are replaced by calcite.

4. Locality 8 miles north of Canon City, Fremont County, Colorado, known as "Bone Yard"; collected by C. A. White and R. T. Hills, 1885; U.S.G.S. Mes. loc. 397. The matrix is a hard, cherty dark-grayish limestone and the fossils are well silicified.

5. Felch's Ranch, Garden Park, 9 miles north of Canon City, Fremont County, Colorado; collected by I. C. Russell, 1888; U.S.G.S. Mes. loc. 17997. The matrix is cherty grayish limestone and the abundant fossils are fully replaced by silica.

6. Quarry Spur section, Colorado City (west end of Colorado Springs), El Paso County, Colorado, collected by G. I. Finlay, 1908; U.S.G.S. Mes. loc. 5420. The matrix is a medium-grained dark-grayish limestone. The shells are calcified.

7. About 100 yards southeast of Vernal Summit on Uncompahgre Tunnel road of Uncompahgre project, Montrose County, Colorado; collected by C. E. Siebenthal, 1904; U.S.G.S. Mes. loc. 3209. The matrix is a medium-grained yellowish limestone. The fossils are in part silicified and in part calcified. Three new species of *Hadrodon* occur in abundance.

8. West side of Gunnison Canyon north of Red Rock Canyon, Montrose County, Colorado; collected by C. E. Siebenthal, 1904; U.S.G.S. Mes. loc. 3212. The matrix is a hard, flint-like dark-grayish limestone. The abundant shells are silicified.

9. SE¼ Sec. 26, T. 14 S., R. 98 W., near the Broughton fruit ranch, Gunnison River, Mesa County, Colorado; about 1 mile northeast of Dominguez station and about 23 miles southeast of Grand Junction; collected by T. C. Yen and V. Evans, 1945; U.S.G.S. Mes. loc. 20322. The matrix is a fine-grained dark limestone and the few shells are calcified.

10. Sec. 25, T. 12 S., R. 101 W.; about 8 miles southwest of Grand Junction and 7/10 mile SE. of Blue Hills, on the north rim of Ladder Canyon, Mesa County, Colorado; collected by T. C. Yen and V. Evans, 1945; U.S.G.S. Mes. loc. 20323. The matrix is greenish-gray shale, and the fossils are abundant.

11. Sec. 24, T. 1 N., R. 3 W. Ute Mer., Mesa County, Colorado; about 2 miles due SW. of Fruita and about 1½ miles to west of Fruita Golf Course; collected by T. C. Yen and V. Evans, 1945; U.S.G.S. Mes. loc. 20324. The matrix is cherty dark-gray limestone. Most of the fossils are silicified but a few are argillaceous. Only *Viviparus reesidei* Yen, n. sp., has been found. Individuals are abundant, including numerous young shells, apparently of the same species. The collection may represent a deeper-water facies of the Morrison formation.

12. Sec. 30, T. 1 N., R. 2 W. Ute Mer., Mesa County, Colorado; about 2 miles slightly south of west from the Fruita Golf Course; collected by T. C. Yen and V. Evans, 1945; U.S.G.S. Mes. loc. 20325. The matrix is of dark-grayish limestone.

13. NW¼SE¼ sec. 34, T. 4 S., R. 92 W., Garfield County, Colorado; 16 feet above the Entrada sandstone; collected by W. L. Stokes, 1944; U.S.G.S. Mes. loc. 19407. The matrix is fine-grained greenish-gray sandstone and the fossils are represented by internal casts of *Unio.*

14. Fairplay-Como road, just east of Red Hill Gap, about 4½ miles NE of Fairplay, Park County, Colorado; collected by David White, 1909; U.S.G.S. Mes. loc. 6220. The matrix is dark-grayish limestone of fine texture. The few shells are calcified.

15. Two miles north of Morrison, Jefferson County, Colorado; collected by C. E. Siebenthal and N. H. Darton, 1905; U.S.G.S. Mes. loc. 3507. The matrix is grayish limestone of fine texture; fossils are few and imperfectly preserved.

16. By road side about ½ mile west of Hot Sulphur Springs, Middle Park, Grand County, Colorado; collected by Whitman Cross, 1891; U.S.G.S. Mes. loc. 6951. The matrix is light-gray limestone of fine texture.

17. Sec. 13, T. 8 N., R. 70 W., Larimer County, Colorado; west side of U. S. Highway 287; collected by T. C. Yen and G. Alexander, 1945; U.S.G.S. Mes. loc. 22408. The matrix is dark-grayish limestone of fine texture.

18. SE¼ sec. 23, T. 9 S., R. 68 W., Castle Rock, Quadrangle, Douglas County, Colorado; collected by B. G. Richardson, 1911; U.S.G.S. Mes. loc. 7363. The matrix is sandy light-gray limestone above a gypsum bed. The fossils are undeterminable forms of pelecypods and gastropods.

19. SE¼NW¼ sec. 28, T. 9 N., R. 80 W., about 7 miles west of Walden, near Platte River bridge, Jackson County, Colorado; collected by A. L. Beekly, 1911; U.S.G.S. Mes. loc. 7119. The matrix consists of rather soft silty shale, and fossils are imperfectly preserved and few in number.

20. SW¼NE¼ sec. 33, T. 10 N., R. 81 W., Jackson County, Colorado; collected by A. L. Beekly, 1911; U.S.G.S. Mes. loc. 7116. Light-gray clayey limestone of fine texture.

21. Blue limestone above upper red beds, Humbug, Wash., Emery County, Utah; collected by E. M. Spieker and J. B. Reeside, Jr., 1924; U.S.G.S. Mes. loc. 12572. *Unio* sp. and fragments of gastropods have been found.

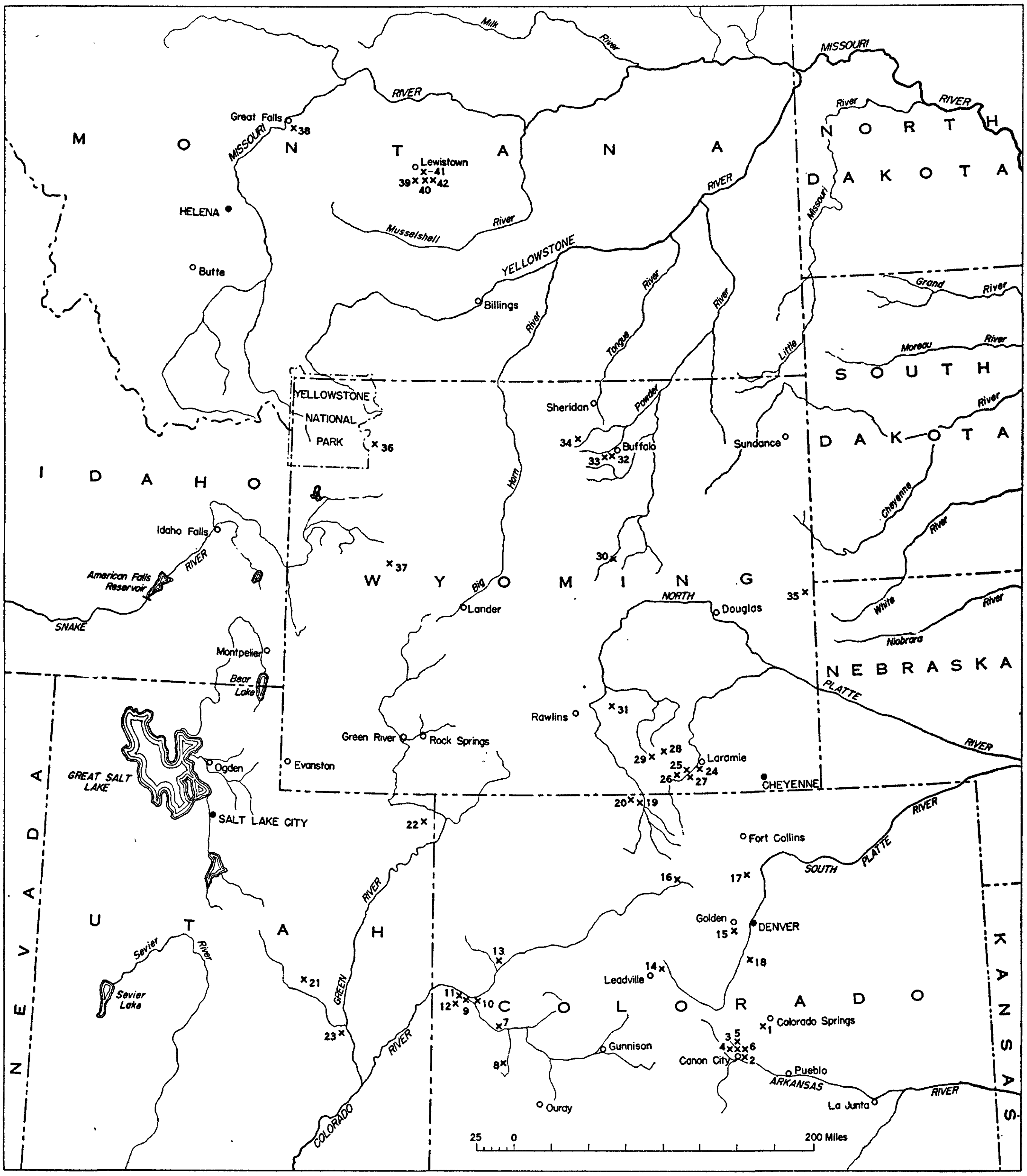


FIGURE 1. Localities of Morrison invertebrate collections.

Distribution of species of Morrison mollusks

***Unio stewardi*, "*Pentagoniostoma*" *altispiratum* Branson, and unidentifiable species of *Valvata*, *Viviparus*, *Amnicola*, *Hydrobia*, *Gyraulus*, *Physa*, and *Unio* are omitted.**

	Vicinity of Canyon City and Colorado City, Colo.						Vicinity of Grand Junction Red Rock Canyon, and Fairplay, Colo.								Vicinity of Morrison and Boulder, Colo.				Northwestern Colorado and Utah					Vicinity of Laramie, Wyo.						Vicinity of Mayoworth and lower Green River Lakes, Wyo.								Montana				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Unio felchi	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
toxonotus	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
macropisthus	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
iridoides	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
baileyi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
lapilloides	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
knighti	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
stewardi utahensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—
willistoni	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
nucalis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—
mammillaris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	×	×	×	×
Vetulonaia whitei	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	×	×	×
mayoworthensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	×	—	—	—	—
faberi	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hadrodon jurassicus	—	—	—	—	—	—	×	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
trigonus	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
lateralis	—	—	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Valvata minuscula	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Amplovalvata cyclostoma	×	×	—	×	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
scabrida	×	—	—	—	—	×	—	—	—	×	—	—	—	×	×	×	—	—	—	—	—	×	×	×	—	×	—	×	×	—	—	—	×	—	—	—	—	—	—	—	—	—
scabrida leei	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Tropidina jurassica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—
Liratina jurassica	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—
Viviparus reesidei	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	×	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
morrisonensis	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—
Lioplacodes jurassicus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Amnicola gilloides	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×	×	—	—	—	×	—	—	—	—	—
jurassica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mesocochliopa assiminoides	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Mesopyrgium pendilabium	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Mesoneritina morrisonensis	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mesauriculstra accelerata	×	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
morrisonensis	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ovalis	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mesochilina spiralis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Zaptychius aff. Z. haldemani	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Limnopsis jurassica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Lymnaea ativuncula	—	—	—	×	×	—	—	×	—	—	—	—	—	—	—	—	×	—	—	×	—	—	—	×	—	—	×	×	—	—	—	—	×	—	—	—	×	—	—	—	—	—
consortis	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
morrisonensis	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gyraulus veternus	—	×	—	×	×	×	—	×	×	—	—	×	—	×	—	—	×	—	—	×	—	×	—	×	—	×	×	—	×	—	—	×	×	—	—	—	×	—	—	—	—	—
Graptophysa spiralis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Physa micra	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
conispira	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Aplexa morrisonana	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
[illegible]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—

22. Near Dinosaur Quarry, Dinosaur National Monument, Uintah County, Utah, collected by Earl Douglas, 1913; U.S.G.S. Mes. loc. 8747. The matrix is a coarse-grained sandstone.

23. Forty feet above base of Morrison formation; 1,000 feet due south of the bridge over San Rafael River on Hanksville Green River Road, about 15 miles SW. of Green River, Emery County, Utah; collected by H. E. Vokes, 1943; U.S.G.S. Mes. loc. 19472. The matrix is rather fine-grained dark-gray sandstone. The fossils are represented by more bivalves than gastropods, though the latter have the wider specific range.

24. SW¼ sec. 32, T. 14 N., R. 74 W., about 12 miles SW. of Laramie, Albany County, Wyoming; collected by N. H. Darton and C. E. Siebenthal, 1905; U.S.G.S. Mes. loc. 3503. The matrix is light-gray limestone of fine texture, and the fossils are calcified.

25. NW¼ sec. 11, T. 14 N., R. 74 W., about 8 miles SW. of Laramie, Albany County, Wyoming; collected by C. E. Siebenthal and N. H. Darton, 1905; U.S.G.S. Mes. loc. 3504. The matrix is fine-grained limestone of light gray color.

26. In NE¼ sec. 10, T. 13 N., R. 76 W., Riverside Ranch, 25 miles SW. of Laramie, Albany County Wyoming; collected by C. E. Siebenthal and N. H. Darton, 1905; U.S.G.S. Mes. loc. 3505. The matrix is fine-grained light-gray limestone.

27. NW¼ sec. 15, T. 13 N., R. 75 W., west of Dowling's Soda Lake, Albany County, Wyoming; collected by N. H. Darton, 1905; U.S.G.S. Mes. loc. 3506. The fossils are few and occur in grayish limestone.

28. Sec. 12, T. 22 N., R. 77 W., about 3 miles east of Como Lake, Albany County, Wyoming; collected by N. H. Darton, 1905; U.S.G.S. Mes. loc. 3508; grayish limestone.

29. Sec. 9, T. 22 N., R. 77 W., Albany County, Wyoming, about 1½ miles north of "Dinosauria" Museum; collected by T. C. Yen and H. A. Tourtelot, 1945; U.S.G.S. Mes. loc. 20326. Grayish-brown shale below the "Dakota" sandstone.

30. North Gulch of Salt Canyon, about sec. 33, T. 41 N., R. 81 W., Powder River Oil Field, Natrona County, Wyoming; collected by C. M. Wegemann, 1910; U.S.G.S. Mes. loc. 6767. Light-gray oil-saturated sandstone at base of the Morrison formation.

31. Hill behind the University of Wyoming cabin, Freezeout Mountains, Carbon County, Wyoming; collected by C. Schuchert, 1899; U.S.G.S. Mes. loc. 2389. The matrix is fine-grained dark-gray sandstone, and the fossil bed is about 6 inches thick and in the middle of a zone 100 feet thick.

32. Near center of sec. 14, T. 44 N., R. 83 W., Johnson County, Wyoming; collected by Vaughn Russom, 1944; U.S.G.S. Mes. loc. 19092. The fossils occur in a reddish-brown sandstone ledge, 1 to 2 feet thick, 50 to 75 feet below top of the Morrison formation.

33. Sec. 14, T. 44 N., R. 83 W., Mayoworth, Johnson County, Wyoming; collected by T. C. Yen and H. A. Tourtelot, 1945; U.S.G.S. Mes. loc. 20327. The fossils occur in grayish-green sandy shale.

34. NE. of Bonanza Post Office, about sec. 12, T. 49 N., R. 91 W., Wyoming; collected by W. C. Knight, 1903; U.S.G.S. Mes. loc. 3184. The fossils are weathered from a light-colored, rather fine-grained sandstone.

35. Basal beds of the Morrison formation in Old Woman anticline, Niobrara County, eastern Wyoming; collected by Harold J. Cook, 1945; U.S.G.S. Mes. loc. 20533.

36. North side of Big Goose Creek, Absaroka Park, 1¼ miles below mouth of Big Goose Canyon, about sec. 35, T. 55 N., R. 86 W., Sheridan County, Wyoming; collected by T. E. Williard, 1907; U.S.G.S. Mes. loc. 4884.

37. West of Mill Creek below Lower Green River Lake, on the west slope of Wind River Mountains, Sublette County, Wyoming; collected by G. Richmond, W. G. Pierce, and J. D. Love, 1944; U.S.G.S. Mes. loc. 20328. Hard, cherty light-gray limestone; the shells are fully silicified.[2]

38. About 2 miles north of Pools Ranch on Surprise Creek, Great Falls coal field, near Fergus-Cascade County line, Montana; collected by C. A. Fisher, 1906; U.S.G.S. Mes. loc. 3963. The martix is rather fine-grained dark sandstone.

39. North of springs on Big Spring Creek, about 7 miles SE. of Lewiston, Fergus County, Montana; collected by W. R. Calvert, C. A. Fisher and T. W. Stanton, 1907; U.S.G.S. Mes. loc. 4763. Light-colored silty limestone 40 feet above the base of the Morrison.

40. On east side of the creek at Big Springs NW. corner of Big Snow Mountains, Fergus County, Montana; collected by R. W. Brown, O. O. Mueller, and R. W. Imlay, 1944; U.S.G.S. Mes. loc. 19418. Greenish shale near the base of the Morrison formation.

41. About 3 miles south of Cheadle, Fergus County, Montana; collected by J. B. Reeside, Jr., and R. W. Imlay, 1944; U.S.G.S. Mes. loc. 19419.

42. NE¼SE¼ sec. 5, T. 14 N., R. 19 E., Judith Basin, Fergus County, Montana; collected by W. R. Calvert, 1907; U.S.G.S. Mes. loc. 4768.

Insofar as the available collections show, the invertebrate fauna of the Morrison, in addition to the molluscan species, consists of ostracodes of fresh-water habitat and in places spicule-like remains which are assumed to represent fresh-water sponges. No other invertebrates have been found.

The fossil flora of the formation consists chiefly of *Charophyta*, represented by oogonia and by stems. These occur commonly and in places very abundantly. According to Peck (1937, 1941), the charophyte faunas of the Morrison (Upper Jurassic) and of Lower Cretaceous beds are distinct and can easily be distinguished. If the strata below the coal bed in the lower part of the Kootenai formation in Montana, which are about 75 feet thick, and the underlying unit of shales, about 125 feet thick, be included in the Morrison (Brown 1946), the flora of this formation may be enriched by some 19 species of ferns, cycads and conifers.

AGE OF THE MORRISON FORMATION

The age of the Morrison formation has been a matter of controversy for more than half a century.

[2] J. D. Love reports (Letter of January 5, 1951) that R. E. Peck has found at this locality charophyte oogonia and an ostracode of Early Cretaceous age. Because the molluscan fauna includes four species in common with accepted Morrison localities and none with any known Lower Cretaceous locality, the writer has retained the locality as Morrison. It is the only known locality for *Zaptychius* not definitely of Cretaceous age.

Baker, Dane, and Reeside (1936, pp. 58–63) reviewed the discussions to 1936 and little has been added since that time. It seems to be more generally accepted in recent years that these deposits were laid down in Upper Jurassic time (pp. 33-34).

CHARACTERISTIC SPECIES OF MOLLUSKS

Study of the molluscan species from 42 localities in Colorado, Utah, Wyoming, and Montana, has convinced me that an assemblage of a few of the following species, or their association with the less abundant species, is a good indication of the presence of the Morrison formation.

Unio lapilloides White
Unio stewardi utahensis Yen
Unio mammillaris Yen
Vetulonaia mayoworthensis Branson
Vetulonaia whitei Branson
Hadrodon jurassicus Yen
Amplovalvata cyclostoma Yen
Amplovalvata scabrida (Meek and Hayden)
Viviparus reesidei Yen
Viviparus morrisonensis Yen
Lymnaea ativuncula White
Gyraulus veternus (Meek and Hayden)

The table of distribution shows that all the species listed above occur at 2 or more localities, and in general fairly abundant. None of these species has been recorded from beds above or below the Morrison formation.

Generic identifications of fresh-water mollusks generally give little help in determining the age of the containing rocks, for most of them have long ranges. However, the following genera have been as yet reported from beds of the Morrison formation only:

Vetulonaia Branson
Hadrodon Yen
Amplovalvata Yen
Mesopyrgium Yen and Reeside
Mesauriculstra Yen
Limnopsis Yen

COMPARISON WITH MOLLUSCAN FAUNAS OF OVERLYING BEDS

Only a few species of mollusks have been reported from such older fresh-water units as the Chinle formation, of Upper Triassic age, which is separated from the Morrison by a considerable sequence of deposits, part of which are marine and recognized to be of Jurassic age. Therefore, for the purpose of the present work, a comparison with the beds overlying the Morrison may be more advantageous.

Stanton (1915) compared the molluscan fauna of the Morrison with the scant fauna of the Potomac group of Maryland and with that of the Kootenai formation of Montana. The fossils from Maryland came from the Arundel and Patapsco formations and these units have recently been placed in the Upper Cretaceous (Anderson, 1948), which assignment removes the fossils from consideration here. The Kootenai formation is accepted as of Lower Cretaceous age. Stanton concluded that the Lower Cretaceous mollusks are decidely distinct, specifically as well as in assemblage, from those of the Morrison. The writer reached a similar conclusion (1946) after studying a collection of fresh-water mollusks from the Cloverly formation on Sage Creek, Wyoming. The difference is easily recognizable even by comparing the molluscan species of the deposit at Sage Creek with those of the Morrison exposed near Lower Green River Lake only 100 miles away. The Lower Cretaceous beds are commonly indicated by the presence of such species as—

Protelliptio douglassi (Stanton)
Protelliptio douglassi hamili (McLearn)
Eupera onestae (McLearn)
Stantonogyra silberlingi (Stanton)
Lioplacodes veternus (Meek and Hayden)
Lioplacodes cretaceus (Stanton)
Lioplacodes convexiculus Yen

None of these species has been found in any of the Morrison collections available for the present study.

Congeneric species are known from both the Jurassic and Lower Cretaceous formations, and the relationships of the congeneric forms are close. This element in the two faunas is not large, but the number may increase as the molluscan fauna of the Lower Cretaceous beds becomes better known. The following may be noted:

Jurassic	*Lower Cretaceous*
Viviparus reesidei Yen	*Viviparus gilli* (Meek and Hayden)
Lioplacodes jurassicus Yen	*Lioplacodes cretaceus* (Stanton) *Lioplacodes veternus* (Meek and Hayden)
Mesoneritina morrisonensis Yen	*Mesoneritina nebrascensis* (Meek and Hayden)
Zaptychius aff. *Z. haldemani* (White)	*Zaptychius* cf. *Z. haldemani* (White)

On the basis of the above discussion, the Morrison formation is not the faunal equivalent of the Kootenai and Cloverly formations. As the stratigraphic position of these formations in most places is above the Morrison, it is logical to conclude that the Morrison formation is older than the Kootenai and Cloverly.

COMPARISON WITH MOLLUSCAN FAUNAS OF EUROPEAN DEPOSITS

The fauna of the Morrison formation has been compared during the last three-quarters of a century with those of Purbeckian and Wealden beds of Europe. Jones (1885) compared several species of ostracodes collected from the "*Atlantosaurus* beds" north of Canyon City, Colorado (Locality 4), with those described from the Purbeck beds of England. Osborn (1888) related the mammals of the Morrison to those of the British Purbeck. Although the molluscan fauna of the Morrison has been studied at intervals during the last 70 to 80 years, no serious comparative study of its species with contemporary forms from other parts of the world has been undertaken. Logan (1900) mentioned the similarity of four Morrison genera, *Unio, Valvata, Planorbis,* and *Viviparus,* to those of the Wealden, but he seems to have overlooked the fact, pointed out by Stanton (1915), that the genera considered by Logan are all known from formations both older and younger than the Wealden. Besides, Logan was evidently not aware that most of the genera of fresh-water mollusks have long geological ranges and so are of little use, for purposes of correlation.

On the basis of collections in the British Museum and the Museum of Practical Geology of the Geological Survey of Great Britain, the Morrison molluscan species are compared with the Purbeckian and the Wealden faunas. Because less is known concerning the morphological features of the species of pelecypods, the present comparison lays emphasis mainly on the gastropod species.

PURBECK FAUNA

On the basis of the available collections, none of the Morrison forms is specifically identical with any found in the Purbeck beds. However, of the 26 species described and accepted by Arkell (1941), 8 show a morphological resemblance to Morrison species. For the European species, I retain Arkell's nomenclature; however, I am inclined to believe that the respective similar forms are probably congeneric, and that the differences in nomenclature may be adjusted later.

Morrison species	*Purbeck species*
Valvata minuscula Yen and Reeside	*V. helicoides* de Loriol *V. subaudiensis* Maillard
Lioplacodes morrisonensis Yen	*Viviparus cariniferus* (J. Sowerby)
Hydrobia sp. undet.	*H. chopardiana* (de Loriol)
Mesopyrgium pendilabium Yen and Reeside	*Promathilda microbinaria* Arkell
Mesoneritina morrisonensis Yen	*Theodoxus fisheri* Arkell
Mesauriculstra morrisonensis Yen	*Ellobium durlstonense* Arkell
Gyraulus veternus (Meek and Hayden)	*Planorbis fisheri* Arkell

First of all, the two Purbeckian species of *Valvata* are decidedly different from the Morrison species in the lower elevation of the spire, coarser sculpture, and wider umbilicus. *Viviparus cariniferus* and *V. inflatus* of the Purbeck beds are elongately high-spired, have strongly and roundly convex whorls, and the former is probably keeled in the young shells along the periphery. These features remind one of those of *Lioplacodes morrisonensis,* which is described from the Freezout Mountains of Wyoming. The peripheral keel of the Morrison species is obscure but traceable on the body whorl of the adult. *Hydrobia chopardiana* resembles closely, except in its smaller size, a species recorded from Locality 26 of the Morrison formation. This species is represented by a single example, so that its specific identification remains uncertain. One of the most interesting species of the Morrison is perhaps *Mesopyrgium pendilabium,* which morphologically resembles *Promathilda microbinaria* of the Purbeckian. However, according to Arkell, the Purbeckian species occurs in the middle Purbeck above the Cinder Bed in association with species of brackish habitat, whereas the Morrison species is found with truly fresh-water species of *Amnicola, Planorbis, Physa,* and *Aplexa.* Whether *Theodoxus fisheri* is comparable with *Mesoneritina morrisonensis* will have to depend largely on the discovery of better-preserved specimens of the Purbeck species, which may show its columellar plate and apertural features. The Morrison species is of truly fresh-water habitat, found in association with species of *Unio, Amplovalvata,* and *Amnicola.* Among the pulmonates, *Mesauriculstra morrisonensis* seems to be comparable with *Ellobium durlstonense* of the Purbeck beds. The Morrison species bears only a single oblique fold or plait on the columella. It is probably related to species of *Ellobium* and *Auriculstra,* moreover, *Gyraulus veternus,* a widely distributed species in the Morrison formation, is different from *Planorbis fisheri,* not only by its less strongly carinated periphery, but also by its much less rapidly increasing size of whorl, which produces a considerably different outline of the shell. However, they may belong to the same group.

The morphological features seem to deny any specific identity of these possibly related species. But they may be examined in assemblages, for which the fossils of a middle Purbeck bed exposed in Portisham, Dorest, may be taken as a group to compare with the molluscan faunules found north of Canyon City, Colorado (Locality 5), and west of Mill Creek, Wyoming (Locality 37). The British Museum's collection from the Purbeck in Portisham contains the following species:

Valvata helicoides de Loriol
Viviparus subangulatus (Roemer)
Hydrobia forbesi Arkell
Ellobium jaccardi (de Loriol)
Planorbis fisheri Arkell
Physa cf. *P. bristovii* Phillips
Physa sp. undet.

In addition to the above gastropod species, I found several ostracodes and some well preserved oogonia of charophytes with a few fragments of stem-like structures. The abundance of individuals of *Valvata helicoides* and *Hydrobia forbesii*, including numerous young shells leads to the inference that the deposit represents a deeper-water facies (in contrast to a shore deposit). The pulmonate species constitute a bare majority, but they are represented by only a few specimens. The dominance of mollusks in the assemblage, together with charophytes and ostracodes, suggest a similarity in ecological conditions with those of the Morrison formation.

WEALDEN FAUNA

It is difficult to compare the molluscan species of the Wealden with those of the Morrison because the Wealden species have not been studied in detail during recent years, as the Purbeckian species have by Arkell. The Wealden species were described and recorded from the English beds mostly by J. Sowerby from 1813 to 1836, from the German beds by Roemer (1835), Koch and Dunker (1837), Dunker (1846), Sandberger (1870), and Struckmann (1880). On the basis of these records, a list of the Wealden Mollusca was given by von Bubnoff (1935, p. 917). However, both Dunker and Struckmann included several Purbeck species in their Wealden division. Struckmann actually treated part of the Purbeck beds as his Lower Wealden.

In the collections of Wealden Mollusca in the British Museum (Natural History) and the Museum of the Geological Survey of Great Britain, I have found some characteristic species from the Wealden beds exposed in Sussex, Kent, and Ise of Wight. The occurrence of a few of these species in combination may be taken as a good index of this formation, and these forms are listed as follows:

Anodonta becklesi Newton
Unio valdensis Mantell
Neomiodon medium (J. Sowerby)
Viviparus sussexiensis (J. Sowerby)
Campeloma carbonaria (Roemer)
Lioplacodes elongatus (J. Sowerby)
Amnicola roemeri (Dunker)
"Paludina" scalariformis (Dunker)
Paraglauconia strombaeformis (Schlotheim)

The assemblage of molluscan species from the Wealden shows considerable difference from that of the Purbeck. So far the true Wealden species of mollusks have not been reported from the Purbeck beds. Such a common Wealden species as *Lioplacodes elongatus* (J. Sowerby) is readly differentiated from the common Purbeck species *"Viviparus" cariniferus* (J. Sowerby) by its scracely convex whorls, smaller number of whorls at similar size of shell, and absence of an infraperipheral keel in the early whorls.

The molluscan fauna of the Morrison shows even greater difference from that of the Wealden than from that of the Purbeck. Of three genera of pelecypods, only *Unio*, and three of nine genera of gastropods (*Viviparus*, *Lioplacodes*, and *Amnicola*) are common to the Morrison and Wealden formations. The congeneric species are distinctly different from each other, and the common occurrence of such genera as *Unio*, *Viviparus*, and *Amnicola* has practically no significance in stratigraphical interpretation.

CONCLUSION

The foregoing comparisons of the molluscan faunas suggest that probably the Morrison formation is older than the Purbeck formation, and that there is little basis for correlating it with the Wealden beds.

It is true that in places the assemblages of the Morrison and Purbeck show close similarity in ecological conditions, and the congeric species of the two formations also indicate close relationship. I also readily agree with Arkell that a number of the Purbeck species, some of which I have had the opportunity of examining, resemble species of the Bear River formation, of Late Cretaceous age. However, there is no species found both in the Morrison and Purbeck formations, even of such widely distributed genera as *Planorbis*, *Lymnaea*, and *Physa*. Moreover, *Pachychilus*-like or *Goniobasis*-like species are not known in formations earlier than the Purbeck and do not occur in the Morrison, but they have been repeatedly reported from Cretaceous and Early Tertiary horizons in North America as well as in Europe. The absence of these faunas in the Morrison, therefore, suggests that the Morrison is older than the Purbeck. Conceivably, it could be contemporaneous with the basal part of the lower Purbeck, or with some unit between the Portlandian and the Purbeckian, but in my judgment it is older than the Purbeckian at least.

SYSTEMATIC DESCRIPTIONS

PELECYPODA

The bivalves of the Morrison formation, so far as the collections available for the present study are concerned, are represented by Unionids only. On account of lack of knowledge of the hinge features in several species, the generic revision of these forms is exceedingly difficult, if not impossible. Though such a generic name as *Vetulonaia* is useful, caution should be exercised when insufficiently described species of the early records are included under such genera. The change may add nothing but confusion.

Hadrodon Yen, new genus, is distinguished both by external features and by hinge structure. Nothing closely similar has been found in younger rocks, so far as I know. Some of the features show a gerontic character, and the genus may have become extinct shortly after Morrison time.

The possible origin of the North American Jurassic Unios is still a problem, and divergent opinions have been advanced. One school believes that these fresh-water bivalves migrated from another continent during the Jurassic time, whereas others consider that they existed in America in Triassic or even earlier times. *Unio thomasi* Henderson and *Unio arizonensis* Henderson, both from the Triassic beds of Arizona, seem to lend weight to the latter viewpoint. However, any generalization on the basis of incidental collections of material seems to be inadvisable. It seems reasonable to suppose that other genera of fresh-water bivalves of wide geographic distribution could exist together with the true unios in America, subsequently becoming extinct here but surviving elsewhere.

Family UNIONIDAE

Unio felchi White

Pl. 3, fig. 1a-c.

Unio felchi White, U. S. Geol. Survey Bull. 29, p. 16, pl. 1, fig. 1–5, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20048) consists of 3 specimens. They are closed valves and the hinge structure is unknown. The original description of the external features is adequate and accompanied by illustration of the 3 specimens.

Figured specimen: U.S.N.M. 106992.

Unio toxonotus White

Pl. 5, fig. 3a-b.

Unio toxonotus White, U. S. Geol. Survey Bull. 29, p. 17, pl. 2, fig. 1–2, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20049) consists of a single specimen with closed valves, slightly injured at its ventral margin.

Unio macropisthus White

Pl. 5, fig. 4.

Unio macropisthus White, U. S. Geol. Survey Bull. 29, p. 17, pl. 2, fig. 7, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20050) is a single internal mold. Further interpretation of this species will depend upon the discovery of more completely preserved specimens at the type locality.

Unio iridoides White

Pl. 5, fig. 5a-b.

Unio iridoides White, U. S. Geol. Survey Bull. 29, p. 17, pl. 2, fig. 3–4, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20051) consists of 2 specimens, a complete one with closed valves and an internal mold. The original figures are reproduced.

Unio baileyi Logan

Pl. 3, fig. 2.

Unio baileyi Logan, Kansas Univ. Quart., vol. 9, p. 134, pl. 31, fig. 4, 6, 8, 11 1900. (Type locality: the Freeze-Out Hills Wyoming).

The type-specimen is not available. Judged by the original description and inadequate outline figures, it seems to be close to, if not identical with, the preceding species.

Figured specimen: U.S.N.M. 106991.

Unio lapilloides White

Pl. 5, fig. 6a-b.

Unio lapilloides White, U. S. Geol. Survey Bull. 29, p. 18, pl. 2, fig. 5–6, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20052) consists of an internal mould, characterized by an elongate outline which differentiates it from congeneric species found in this area.

Unio knighti Logan

Unio knighti Logan, Kansas Univ. Quart., vol. 9, p. 134, pl. 31, fig. 7–9, 1900. (Type locality: the Freeze-Out Hills, Wyoming).

It differs from the other two species of *Unio* described by Logan from the same locality mainly in its more elongate outline. The type specimen is not available. It may be closely related to, if not identical with, the preceding species.

Unio stewardi White

Unio stewardi White, in Powell, Report on the geology of the eastern portion of the Uinta Mountains, p. 110, 1876. (Type locality: Jurassic strata near the banks of the Green River in southern Wyoming).

The type lot (U.S.N.M. 8849) consists of 6 fragments, which are recognizable as a large species of *Unio* of thick shell substances.

Unio stewardi utahensis Yen, n. sp.

Pl. 3, fig. 3a-e.

This subspecies is characterized by its subtriangular outline, broadly undulated external surface, and moderately thick shell substance. The pseudocardinal is well developed and moderately elevated. The hinge line is gently curved, having a single prominent lateral ridge on the right valve, that corresponds with a fairly deep groove on the left. The type measures 28.0 mm in length, 58.0 mm in height, and 34.0 mm in convexity.

In the type collection, there is a large series of well-preserved specimens with both open and closed valves, which were obtained by H. E. Vokes from a locality in Utah (no. 23), less than 200 miles southwest of the type-locality of *Unio stewardi* White.

Holotype: U.S.N.M. 106989, Locality 23; figured paratypes: U.S.N.M. 106990, unfigured paratypes: U.S.N.M. 107031a-n, Locality 23.

Unio willistoni Logan

Pl. 3, fig. 4.

Unio willistoni Logan, Kansas Univ. Quart., vol. 9, p. 133, pl. 31, fig. 10, 1900. (Type locality: The Freezeout Mountains, Wyoming).

The type lot is not available for the present study. A number of specimens that Charles Schuchert collected from the Freezeout Mountains externally seem to be identical with this species.

Figured specimen: U.S.N.M. 106994.

Unio nucalis Meek and Hayden

Pl. 3, fig. 5a-c.

Unio nucalis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 10, p. 52, 1858. (Type locality: southwest base of Black Hills, South Dakota).

The type lot (U.S.N.M. 196) consists of 5 specimens, 2 with closed valves, 1 with its hinge line partly preserved, and 2 buried in a grayish limestone matrix.

In the present collection there are several specimens that were obtained from the basal bed of the Morrison formation in the "Old Woman Anticline in eastern Wyoming." These new well-preserved specimens are rather small, have moderately thick shells, highly convex valves, and a high but small pseudocardinal and a single prominent lateral in the right valve.

Figured specimen: U.S.N.M. 103749.

Unio mammillaris Yen, n. sp.

Pl. 4, fig. 1a-e.

Shell large and of very thick substances, oval to subtriangular in outline. External surface bears strong and close concentric lines of growth and one broad, radiating fold at some distance below the dorsal margin. Beaks high and prominent, at anterior end of the shell, well incurved and pointed somewhat forward. Beak sculpture not well preserved on the holotype. Hinge structure massive and strong, consisting of wide plate. Pseudocardinal large and heavy, of subtriangular form, with its top surface rugged, as shown on better-preserved specimens; single on the right, distinctly but unequally bisected on the left. Lateral single, prominent, and somewhat sharp edged on the right, bound by a well-incised line on both outer and inner margins; laterals 2 on the left valve, forming a rather deep and wide groove corresponding to the single lateral on the right, and a deep canaliculate line running externally next to the outer lateral. The anterior adductor scar is large, deep, and rough on its surface; the posterior scar as shown on an incomplete specimen, appears to be large but shallow. The measurements of the holotype, in millimeters, are as follows:

Altitude of shell	53.0
Length of shell	82.0+
Convexity of shell	47.0

This species is characterized by the heavy structure of the hinge with a rather wide plate, and thick shell substance. The development of the outer and inner incised lines along the laterals is rather variable. In some specimens they are deeply impressed, and often produce an appearance of having 2 laterals on the right valve and 3 on the left. No specimens in the present collections show much secondary laterals distinctly.

Holotype: U.S.N.M. 107064, Locality 39; paratypes: U.S.N.M. 107030, 106993, 107027, 107029 and 107028, Localities 34, 39-42.

Vetulonaia whitei Branson

Pl. 3, fig. 6a-b.

Vetulonaia whitei Branson, Jour. Palaeontology, vol. 9, p. 517, pl. 56, fig. 1–5, 8–10, 13, 15, 19, 1935. (Type locality: 3 miles south of Mayoworth, Wyoming).

The paratype lot (U.S.N.M. 75499) consists of 3 single valves and 3 closed specimens. One of the closed specimens has perfectly preserved traces of the radiating lines on the umbonal area that are much less coarse than the concentric lines.

Vetulonaia mayoworthensis Branson

Pl. 3, fig. 7.

Vetulonaia mayoworthensis Branson, Jour. Palaeontology, vol. 9, p. 517, pl. 56, fig. 7, 11, 14, 16–18, 1935. (Type locality: 3 miles south of Mayoworth, Wyoming).

This species differs from the preceding mainly in its elongate outline and more massive hinge structure and thicker shell substance.

The genus resembles *Pleurobema,* as noted by Branson. The above described forms certainly remind one of such species as *P. decisa* and *P. cordatum* of the living North American fauna but, because of the long time interval, it appears desirable to retain the name *Vetulonaia* for the Jurassic species, as we know nothing at present of the genetic relationships.

Vetulonaia faberi Holt

Vetulonaia faberi Holt, Jour. Palaeontology, vol. 16, p. 459, pl. 69, fig. 1–5, 1942. (Type locality: On Ladder Canyon road, about 6 miles south of Grand Junction, Colorado).

This species, on the basis of the holotype, may be differentiated from *V. whitei* by its more oval outline, greater convexity, and wider and somewhat impressed ligamental area. Holt seems to have included heterogenous forms in his species. One of his paratype specimens (U.S.N.M. 103262), which is illustrated by his figures 3a and b of plate 69, may represent a different form.

Hadrodon Yen, n. gen.

Shell of thick substance, triangular to rhomboid in outline, with a prominent umbonal region. Beak subterminal, well incurved, and bearing a few coarse concentric ridges. External surface conspicuously undulated by 2 or 3 broad, radiate folds and marked by strong concentric lines. Hinge very strong, having a broad plate, which in some species constitutes nearly one-fourth of the entire shell width. The margin of the hinge plate is well defined by a strong convex radiating ridge on the external surface of the shell, which forms a principal undulation on its surface. Pseudocardinal well developed, of triangular shape with rugged surface, bearing irregular and broken molar-like lines; one or two on the right valve, two or four on the left. The laterals are much more strongly developed; the primary one on the right valve is strongly elevated, gradually increasing in width towards the posterior end; it corresponds to a deep and wide canaliculate groove formed on the left valve. In some species, a secondary lateral is present on the right valve, just above the primary, and the groove formed between the 2 laterals on the right valve just fits a smaller lateral one on the left valve.

Genotype: *Hadrodon jurassicus* Yen, n. sp. The genus is characterized by its broad hinge plate and strong lateral teeth in combination with its conspicuous undulating external surface. In one species, the hinge plate has a tendency toward outward expansion, and in another species, it has an excessive development; such gerontic features seem to suggest that this group of fresh-water bivalves may have been extinct since Jurassic time.

Hadrodon jurassicus Yen, n. sp.

Pl. 4, fig. 2a-f.

Shell features essentially those described for the genus. Shell subrhomboid in outline, convex and bearing costulate concentric lines, and broad radiating folds. One fold forms a strong convex ridge extending from the umbonal area to the posteroventral margin. The hinge plate is well defined; pseudocardinal moderately heavy and elevated, of triangular shape and rugged surface; lateral plate bears single high lateral tooth on the right valve, which corresponds with a deep groove of moderate width, flanked by 2 lower lateral teeth on the left valve. The main anterior adductor scar is broad and deep, with a much smaller secondary one; the posterior scar is larger than the anterior but is shallower; it also has a secondary scar just above it. Measurements of the holotype, in millimeters, are:

Altitude of shell	36.0
Length of shell	44.0
Convexity of left valve	15.5

This species is characterized by its subrhomboid outline of shell, highly elevated pseudocardinal, and comparatively narrow hinge plate.

Holotype: U.S.N.M. 107005, Locality 7; paratypes: U.S.N.M. 106995, 107006, 107007, 107008 and 107009, Localities 7 and 10.

Hadrodon trigonus Yen, n. sp.

Pl. 4, fig. 3a-f; pl. 5, fig. 1a-d.

Shell of subtriangular outline, much more strongly convex than *H. jurassicus*. The radiating ridge is more sharply angulated and submedian in position. The hinge line is arched, having a broader plate; the pseudocardinal is large; the lateral groove on the left valve is wider and more deeply impressed, possibly indicating a much stronger lateral on the right valve. The primary and secondary adductor scars are very similar to those of the preceding species. Measurements of the holotype, in millimeters, are:

Altitude of shell	48.0
Length of shell	66.5
Convexity of shell	40.0

Holotype: U.S.N.M. 107001, Locality 7; paratypes: U.S.N.M. 107002, 107003 and 107004, Locality 7.

Hadrodon lateralis Yen, n. sp.

Pl. 5, fig. 2a-f.

Shell ovately rhomboid in outline, more compact than in *H. jurassicus* or *H. trigonus*. The main ridge on the external surface is convex but low. The hinge plate is very broad, and its superior margin somewhat expanding. The pseudocardinal is low but large. The primary lateral groove on the left valve is wide but less deeply impressed, and has one or two secondary grooves present above it. These grooves correspond to one primary and one or two secondary teeth on the right valve. The arrangement of muscular scars is similar to that of the preceding species. Dimensions of the holotype, in millimeters, are:

Altitude of shell	54.5
Length of shell	67.0+
Convexity of right valve	16.5

Holotype: U.S.N.M. 106997, Locality 7; paratypes: U.S.N.M. 106998, 106999, 107000 and 106-996, Localities 7 and 10.

GASTROPODA

The gastropods of the Morrison formation are aquatic species more heterogeneous than its pelecypods. They are essentially of holarctic type with a small percentage of neotropical elements. A few pectinibranch species somewhat resemble forms living in Lake Baikal in Siberia. It is possible that this morphological resemblance will prove to be a result of genetic relationship of the forms rather than of ecological similarities of the habitat areas, but the long separation in time of the two faunas will demand more extensive collection of material from intermediate horizons and an intensive genetic study of the groups before definite conclusions can be reached.

Because so little information is available concerning Triassic and earlier nonmarine gastropods throughout the world, it is difficult to suggest a possible origin of the molluscan fauna of the Morrison formation. Triassic deposits of fresh-water origin are extensively exposed in various parts of North America and in Europe. From these deposits many species of terrestrial pulmonates and fresh-water bivalves have been described, but only *Ammicola*-like and *Hydrobia*-like aquatic gastropods. The scarcity of fresh-water univalves in collections from these earlier beds may be due to insufficient collection of material, to actual scarcity of individuals in the early stage in evolution of these forms, or to the lack of preservation.

The present collections contain about half of pectinibranch species, which bear opercula and (generally existing in a deeper water zone) respire through a primitive type of gills or ctenidia, and half of pulmonates, which possess a pulmonary chamber for the purpose of respiration. The pulmonary chamber is not morphologically a true lung, although physiologically it performs a similar function. About a third of the pulmonates such as species of Ellobiidae and Otinidae, are generally considered to be primitive, and two thirds more advanced species.

The divergent types included in the gastropod fauna of the Morrison formation make it reasonably certain that these fresh-water forms had a long pre-Morrison history. It is unlikely that lack of preservation has much to do with the scarcity in the earlier beds, as terrestrial pulmonates and fresh-water bivalves are locally abundant. Consequently, the first of the above three possibilities, insufficient collection of material may be the answer. Until our knowledge of these earlier beds is increased we cannot venture an opinion on the origin of the Morrison gastropods.

Family VALVATIDAE

Valvata minuscula Yen and Reeside

Valvata minuscula Yen and Reeside, Jour. Paleontology, vol. 20, p. 53, fig. 1a, b, 1946. (Type locality: west of Mill Creek below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

Typical species of *Valvata* are generally small, of thin shell substance, with more or less flatened or slightly raised apical whorl, roundly convex whorls, descending aperture of circular outline, and open umbilicus. The present form seems to have all these features, though other species from the Morrison formation attributed to this genus are not true *Valvata*, but belong to related genera.

Amplovalvata Yen, n. gen.

Shell globose, more than 10 mm in diameter, moderately thick in substance, umbilicus open, elevated spire and inflated body whorl. Whorls increasing rapidly in size, early ones exserted and angulated, later ones roundly convex, bearing distinct lines of growth with frequent strong riblines. Suture well impressed. Aperture somewhat descending, continuous, almost circular in outline, slightly angular above, having its parietal wall more or less attached to the preceding whorl.

Genotype: *Amplovalvata cyclostoma* Yen, n. sp.

The features of *Amplovalvata* are characteristic of the Valvatidae. The general outline of the shell, the aperture, and umbilicus remind one of *Atropidina* Lindholm and *Cincinna* Ferussac, but its large size and exserted and angular early whorls readily distinguish it from either group of the family. It is also different from *Megalovalvata* Lindholm, a monotypic group described from the living fauna of Lake Baikal, Siberia, in its globose outline, elevated spire, and exserted early whorls.

Amplovalvata cyclostoma Yen, n. sp.

Pl. 6, fig. 1a-f.

Shell cyclophoroid in outline, large, having an exserted spire and rapidly increasing body whorl. Apex small, but early 2 to 3 pointed whorls exserted and obscurely angulated and last 2 whorls rapidly increasing, roundly convex and somewhat descending near the aperture. Suture well impressed. The sculpture consists of coarse and fine growth lines. Aperture circular in outline, peristome continuous and moderately thick, having its parietal wall closely attached to the penult whorl. Umbilicus open.

Measurements of four specimens, in millimeters, are as follows:

Altitude of shell	13.2	11.2	10.8	9.0
Width of shell	14.1	12.6	12.0	10.0
Diameter of aperture	7.2	6.5	6.0	5.2
Diameter of umbilicus	3.2	3.0	3.0	2.7
Number of whorls	5½	5	5	4¾

This species differs from *Amplovalvata scabrida* (Meek and Hayden) in its higher and exserted spire, more rounded aperture, and narrower umbilicus. The whorls increase more rapidly in size, are more roundly convex and bear strong sculpture.

Holotype. U.S.N.M. 107015, Locality 5; paratypes: U.S.N.M. 107016 and 107042, Localities 1, 2, 4, 5, and 8.

Amplovalvata scabrida (Meek and Hayden)

Pl. 6, fig. 2a-o.

Valvata? scabrida Meek and Hayden, Smithsonian Contribution to Knowledge, No. 172, p. 113, pl. 4, fig. 2a, 1865. (Type locality: Southwest base of Black Hills, South Dakota.)

Vorticifex stearnsii White, U. S. Geol. Survey Bull. 29, p. 21, pl. 4, fig. 4–7, 1886. (Type locality: "Atlantosaurus beds," Como, Wyoming).

The holotoype (U.S.N.M. 316) is an immature specimen attached to a piece of shell, possibly of the same individual, imbedded in limestone. The specimen agrees well with the original description of the species, although the figure does not clearly show the shoulder and peripheral angulations.

The holotype consists of 3 rapidly increasing, angulated whorls measuring about 2.8 mm in width of shell. It is identical with young specimens of *Vorticifex stearnsii* White, the type of which was available for comparison, and several other specimens from the Morrison formation near Mayoworth, Wyoming, and Grand Junction, Colorado. The fully mature shell consists of about 5 whorls, rapidly increasing in size, early whorls angulated and later whorls more strongly convex and slightly shouldered above. These whorls are separated by a deeply impressed suture and bear coarse growth lines.

The measurements of a mature specimen in millimeters are:

Altitude of shell	11.0
Width of shell	14.4
Height of aperture	8.0
Width of aperture	7.6
Diameter of umbilicus	3.6
Number of whorls	4½

The size and features of the early whorls exclude this species from *Valvata,* while its depressed but not planorboid spire and deeply impressed suture, together with its almost circular aperture in the adult form, prevent its being referred to *Vorticifex* and *Carinifex,* two genera of Planorbidae so far known only from late Tertiary to Recent deposits.

Figured specimens: U.S.N.M. 107010, 107011, 107012 and 107013.

Amplovalvata scabrida leei (Logan)

Pl. 6, fig. 3a-c.

Valvata leei Logan, Kansas Univ. Quart., vol. 9, p. 133, pl. 31, fig. 1–3, 1900. (Type locality: the Freeze-Out Hills, Wyoming).

The type is not available for this study. The specimens from the type locality contained in the present collection are somewhat distorted, though they seem to agree well with Logan's description. Judged by the examples available and by Logan's description and figure, the form is close to *Amplovalvata scabrida* (Meek and Hayden), but differs in having only three whorls at a maximum diameter of the shell of 13.0 mm, whereas the adult individual of *A. scabrida* has a width of shell 14.4 mm with 4½ whorls.

Figured specimen: U.S.N.M. 107014.

Tropidina jurassica (Branson)

Pl. 6, fig. 4a-c.

Pentagoniostoma jurassicum Branson, Jour. Paleontology, vol. 9, p. 520, pl. 57, fig. 4–6, 1935. (Type locality: 3 miles south of Mayoworth, Wyoming).

The species was described as the genotype of a new genus, which was considered by Branson to be close to *Adeorbis supranitidus*. Woodward (Wood, 1842, p. 530). *Adeorbis Wood* (=*Tornus* Turton and Kingston in Carrington, 1830) is a true marine genus and was described as having "an incipient sinus in the upper part of the aperture," which is characteristically different from an angulation formed by a strong carina.

Among fresh-water mollusks, this species shows close resemblance to *Tropidina tricarinata* (Say) and *T. bicarinata* Lea, to which group it is here assigned. *Tropidina* H. and A. Adams, 1854, generally considered a subgenus of *Valvata* Mueller, 1774, also includes a few species from late Tertiary deposits. Its long geological range, in addition to its characteristic shell features, justify its assignment as a distinct genus of the Valvatidae.

Figured specimen: U.S.N.M. 107063.

Liratina jurassica (Branson)

Pl. 6, fig. 5a-c.

Valvata? jurassica Branson, Jour. Paleontology, vol. 9, p. 519, pl. 57, fig. 7–8, 1935. (Type locality: 3 miles south of Mayoworth, Wyoming).

One almost perfectly preserved specimen, which was collected from Mayoworth, Wyoming, in 1945, and a few less perfectly preserved examples from other localities, agree well with this species.

It is characterized by its linear spiral sculpture, together with its slowly rising apex and depressed spire, and by an oblique aperture with continuous peristome and open umbilicus, more or less defined outwardly by an obscure angulation. Its spiral sculpture is evenly developed and more distinctly shown on the body whorl. The type is described as having 4 whorls, though the illustration of the apical view shows only about 3 whorls.

The measurements of the figured specimen in millimeters are:

Altitude of shell	2.8
Width of shell	4.5
Height of aperture	1.8
Width of aperture	2.1
Diameter of umbilicus	1.6
Number of whorls	3⅔

The general outline of the shell, its sculpture, and the features of the aperture and umbilicus remind one *Liratina baicalensis* (Gerstfeldt), a Recent species described from Lake Baikal. As all the preserved features of this form indicate much difference from any of the species of *Valvata,* it seems more reasonable to assign this Jurassic species to *Liratina.*

Figured specimen: U.S.N.M. 107055.

Family VIVIPARIDAE

Viviparus reesidei Yen, n. sp.

Pl. 6, fig. 6a-e.

Shell subglobose, moderately thick in substance, smaller than the average size of the genotype of the genus, and narrowly umbilicated. Spire highly elevated and body whorl rapidly dilated; the spire nearly equal in height to the body whorl. Whorls increasing very rapidly in size, roundly convex and bearing distinct wavy growth lines. In some examples coarser rib lines intersecting spiral lines produce a malleated appearance on surface of the body whorl. Suture well impressed. Aperture ovate in outline, peristome continuous, outer lip thin and simple, parietal wall well defined and columellar margin slightly oblique. Operculum unknown. Measurements of holotype and one paratype, in millimeters, are as follows:

Altitude of shell	15.0	13.0
Width of shell	13.2	11.0
Height of aperture	9.0	7.0
Width of aperture	8.5	6.2
Number of whorls	5¾	5½

All the shell features seem to show the species a true *Viviparus,* although it is somewhat smaller than most typical species of the genus in the Recent fauna. Numerous adults occur in the highly silicified limestone of the type locality, together with a profusion of young shells apparently of the same species. The young are small and have 3 to 4 whorls.

It may be compared with two *Viviparus*-like species from Lower Cretaceous beds, *V. gilli* (Meek and Hayden) and *Reesidella montanensis* (Stanton). *V. reesidei* differs from *V. gilli* in its broader outline, more convex whorls, and larger aperture; and it differs from *R. montanensis* (which is represented by several good specimens in the type lot) by its larger size with almost the same number of whorls, lower spire, absence of a prominent shoulder on the larger whorls, and ovately shaped aperture. This species differs from *V. morrisonensis* in its much smaller size.

Holotype: U.S.N.M. 107035, Locality 11; paratypes: U.S.N.M. 107,018, 107036, 107017 and 107-022, Localities 11, 20 and 22.

Viviparus morrisonensis Yen, n. sp.

Pl. 6, fig. 7a-d.

Shell large, subglobose, appearing to be of thin substance, having an elevated spire and much dilated body whorl, the former about the same height as the latter. Whorls increasing very rapidly in size (about 1:3 in proportion), gently convex and slightly shouldered below the suture. Fine lines of growth on some specimens. Aperture somewhat descending; outline of whorl surface indicates it is probably of subovate outline with continuous peristome.

Measurements of the holotype and two paratypes, in millimeters, are as follows:

Altitude of shell	40.5	26.0	24.0
Width of shell	35.0	24.5	21.5
Height of aperture	26.0	18.6	15.5
Width of aperture	21.0	14.0	12.5
Number of whorls	4+	4+	4+

This species is much larger than *V. reesidei,* increase much more rapidly in its whorls, and its surface less strongly convex. Its morphological features indicate it to be a species of *Viviparus.* None of the specimens from the type-locality is perfectly preserved and the umbilical features are not known.

One of the specimens from locality 29 shows a moderately opened umbilicus and subovate aperture.

Holotype: U.S.N.M. 107019, Locality 1; paratypes: U.S.N.M. 107020, 107021 and 107065, Localities 1, 25 and 29.

Lioplacodes jurassicus Yen, n. sp.

Pl. 6, fig. 8a-b.

Shell small, ovately oblong in outline, moderately umbilicated, having a highly elevated spire and descending body whorl. Whorls increasing rapidly in size, gently convex, separated by an impressed suture and bearing distinct wavy lines of growth and a carinated angulation on its basal margin. This angulation in some examples disappears on the last third of the body whorl. Aperture subovate in outline with continuous and thin peristome.

Measurements of the holotype and one paratype, in millimeters, are as follows:

Altitude of shell	9.8+	9.2+
Width of shell	7.0	6.0
Height of aperture	5.5	5.0
Width of aperture	4.0	---
Number of whorls	3+	3+

Both measured specimens have the apical whorls (possibly two in number) injured. The species differs from *Lioplacodes veternus* Meek and Hayden, *Lioplacodes cretaceous* (Stanton), and *Lioplacodes convexiculis* Yen, from the Lower Cretaceous beds by its much smaller size, more convex whorls, more rapidly dilated body whorl, and wider umbilicus.

This species has been so far recorded from locality 31 only. All the specimens are somewhat distorted, though the general outline and features are sufficiently well preserved to permit the above description.

Holotype: U.S.N.M. 107054, Locality 31; paratypes: U.S.N.M. 107034 and 107051, Locality 31.

Family AMNICOLIDAE

Amnicola gilloides Yen and Reeside

Pl. 6, fig. 9a.

Amnicola gilloides Yen and Reeside, Jour. Paleontology, vol. 20, p. 54, fig. 2a, b, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

The shell features of the many specimens, and the associated calcareous opercula, indicate that it is a true species of *Amnicola*—a genus surviving to Recent time.

Figured specimen: U.S.N.M. 107061.

Amnicola jurassica Yen, n. sp.

Pl. 6, fig. 10a-b.

Shell ovately oblong in outline, of thin substance, narrowly umbilicated, having conically elevated spire and descendingly inflated body whorl, the spire about the same height as the body whorl. Whorls increasing very rapidly in size, strongly convex, and bearing strong lines of growth and a few sparse spiral lines. In some specimens these spiral lines are indistinct. Suture well impressed. Aperture subovate in outline, having its perlistome thin and continuous; parietal margin well defined.

Measurements of the holotype and of one paratype, in millimeters, are as follows:

Altitude of shell	9.6	10.0+
Width of shell	7.5	8.3
Height of aperture	5.0	6.0
Width of aperture	4.0	5.0
Number of whorls	5	3+

Amnicola jurassica closely resembles *A. gilloides* Yen and Reeside, but is larger and has more strongly convex whorls, and a larger aperture. The holotype has its apical part injured, but it appears to consist of two to three whorls. One of the three imperfectly preserved specimens shows the parietal and columellar margins quite well.

Holotype: U.S.N.M. 107059, Locality 23; paratypes: U.S.N.M. 107032 and 107060, Locality 23.

Mesocochliopa assiminoides Yen and Reeside

Mesocochliopa assiminoides Yen and Reeside, Jour. Paleontology, vol. 20, p. 54, fig. 3a, b, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

The characteristic features of this monotype of the genus are its small size, broadly conical outline, and almost circular, widely opened umbilicus.

Mesopyrgium pendilabium Yen and Reeside

Mesopyrgium pendilabium Yen and Reeside, Jour. Paleontology, vol. 20, p. 56, fig. 4, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of Wind River Mountains, Wyoming).

This species occurs abundantly in the Morrison formation at its type locality, but it is not known elsewhere. Its presence may indicate a shallower-water facies of the Morrison formation in association with a rich growth of vegetation. This suggestion is further supported by the fact that 8 out of 12 species of the gastropods found in the same bed are pulmonates.

Family NERITIDAE

Mesoneritina morrisonensis Yen, n. sp.

Pl. 6, fig. 11a-f.

Shell small, of moderately thick substance, imperforate, having a low but elevated spire and rapidly inflated oblique body whorl. The spire constitutes three-sevenths the height of the body whorl. Whorls increasing rapidly in size, scarcely convex, and bearing fine wavy lines of growth and occasional former outer lip margins. Aperture broadly ovate, with peristome continuous; outer lip thin and simple; inner lip well defined, formed by a nearly flattened, smooth, thick plate. The basal columellar area is somewhat truncated.

Dimensions of the holotype, in millimeters, are as follows:

Altitude of shell	7.8
Width of shell	7.0
Height of aperture	6.0
Width of aperture	5.4
Number of whorls	3 1/3

Mesoneritina morrisonensis differs from *M. nebrascensis* (Meek and Hayden), described from Lower Cretaceous beds, by its narrower outline, higher spire, and borader columellar plate.

Among the specimens available from two localities no colour pattern has been traceable. In some examples, faint spiral lines are visible.

Holotype: U.S.N.M. 107056, Locality 10; paratypes: U.S.N.M. 107033, 107058 and 107057, Localities 10 and 23.

Family ELLOBIIDAE

Mesauriculstra Yen, n. gen.

Shell broadly oblong, ovately elongate, or subfusiform in outline, with an elevated spire and narrowly dilated and descending body whorl. Apical whorl small and pointed. Early whorls increasing gradually and later ones more rapidly, in size. Whorl surface gently convex and bearing fine lines of growth; suture superficially incised. Aperture narrowly oblong in outline, acute at upper part and moderately produced below. Peristome continuous, outer lip margin almost straight and simple, inner lip well defined, bearing a more or less distinct fold at the columella. Umbilicus perforate or narrowly open.

Genotype: *Limnaea? accelerata* White.

The genus differs from *Rhytophorus* Meek, which was described from the Bear River formation, of the Upper Cretaceous by its truly umbilicated shell with pointed apical whorls and much higher spire. It resembles *Auriculstra* Martens, species of which are still living but differs in lacking a transverse parietal plait and a basal sinus. In general, the new genus resembles *Stolidoma* Deshayes, described from Early Tertiary beds of the Paris Basin, in outline but differs in having obtuse apical whorls and an oblique columellar fold instead of a median plait.

Mesauriculstra accelerata (White)

Pl. 6, fig. 12a-b.

Limnaea? accelerata White, U. S. Geol. Survey Bull. 29, p. 20, pl. 4, fig. 12-15, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

White gave a detail description of the species and clearly recognized its characteristic features except the columellar fold, which is well shown on some of the specimens from the type locality. The species is characterized by its subfusiform outline, more highly elevated spire whose height exceeds that of the body whorl, and a distinct oblique fold at the columella.

Measurements of two specimens, in millimeters, are as follows:

Altitude of shell	21.0+	18.0
Width of shell	8.0	7.0
Height of aperture 666	10.0	8.2
Width of aperture	5.0	---
Number of whorls	5+	7½

The larger one of the measured specimens has its 3 or 4 apical whorls injured. The smaller specimen is about the size of the type.

Figured specimens: U.S.N.M. 107049.

Mesauriculstra morrisonensis Yen, n. sp.

Pl. 6, fig. 13a-b.

Shell ovately oblong in outline, narrowly umbilicated, having a highly elevated and gradually tapering spire, narrowly dilated and descending body whorl, the spire slightly greater in height than the body whorl. Early whorls increasing gradually and the last two more rapidly, having the surface gently convex and marked by fine growth lines. Suture well impressed. Aperture narrowly oblong, somewhat acutely angular above and slightly produced at the basal part. Paristome continuous, outer lip thin and smooth, inner lip well defined and somewhat thickened. Columellar fold faint but traceable.

Measurements of the holotype and a paratype, in millimeters, are as follows:

Altitude of shell	15.0	15.5
Width of shell	7.0	7.3
Height of aperture	7.0	7.3
Width of aperture	3.5	4.0
Number of whorls	8	8 1/3

The species differs from *M. accelerata* in its much smaller size with over one whorl more, broader outline, lower spire, and obscure columellar fold.

Holotype: U.S.N.M. 107043, Locality 5; paratypes: U.S.N.M. 107044 and 107048, Locality 5.

Mesauriculstra morrisonensis ovalis Yen, n. subsp.

Pl. 6, fig. 14a-d.

Shell subovate in outline, perforately umbilicated, having an acutely conical spire and narrowly inflated and descending body whorl, the spire smaller than the body whorl. Early whorls increasing gradually, the last two rapidly; the exposed surface scarcely convex and bearing distinct lines of growth. Aperture very similar to that of *M. morrisonensis* but the parietal wall is thinner and the columellar fold is distinct.

Measurements of the holotype and a paratype, in millimeters, are as follows:

Altitude of shell	13.1+	12.1
Width of shell	6.9	6.0
Height of aperture	7.0	6.0
Width of aperture	3.5	3.0
Number of whorls	6+	7

The species differs from the preceding in its more ovate outline, smaller size, lower spire, and distinct columellar fold. The holotype is somewhat decollated, lacking probably one to two whorls.

Holotype: U.S.N.M. 107045, Locality 5; paratypes: U.S.N.M. 107046 and 107047, Localities 4 and 5.

Mesochilina spiralis Yen, n. sp.

Pl. 6, fig. 15a-b.

Shell narrowly ovate in outline, small, imperforate; the spire is about one-third the height of the body whorl. Whorls gently convex, increasing very rapidly in size, bearing strong lines of growth and incised spiral lines over the surface. Aperture elongately ovate in outline, peristome continuous, outer lip simple and slightly produced at the base, inner lip thickened and bearing a single, weak plica just below the parietal margin. Columella short and nearly straight.

Measurements of the holotype and of a paratype, in millimeters, are as follows:

Altitude of shell	6.2+	7.8+
Width of shell	4.3	4.5
Height of aperture	4.0	5.2
Width of aperture	2.2	2.8
Number of whorls	2.5+	3.0+

Both of the measured specimens have their apical whorls injured.

Holotype: U.S.N.M. 107037, Locality 20; paratypes: U.S.N.M. 107038, Locality 20.

Zaptychius aff. Z. haldemani (White)

Tortacella aff. *T. haldemani* (White) Yen and Reeside, Jour. Paleontology, vol. 20, p. 56, fig. 5, 1946.

There seems to be little doubt that this Jurassic species is congeneric with the form described from Upper Cretaceous beds, though the single imperfect specimen available does not permit a satisfactory specific identification. It seems to have a broader outline, lower altitude of the shell and more convex whorls than *Z. haldemani*. If these differences are substantiated by additional specimens the form might justifiably be considered a distinct species.

Family OTINIDAE

Limnopsis Yen, n. gen.

Shell of moderate size, thin substance, globosely ovate outline, having a distinct but small and elevated spire and more or less laterally dilated body whorl, the latter constituting four-fifths of the entire shell. Whorls increasing very rapidly, and bearing distinct growth and spiral lines. Aperture large, ovate in outline, outer lip thin and simple, parietal wall imperceptable and columellar margin short.

Genotype: *Limnopsis jurassica* Yen, n. sp.

In general form *Limnopsis* resembles *Otina* Gray, a genus of amphibious habitat in the Recent fauna, but I am a little hesitant in referring it to the Otinidae, whose survivors are very few and much restricted. It differs from *Otina* Gray in its greater spire and larger penult whorl, and in its cancellated sculpture.

Limnopsis jurassica Yen, n. sp.

Pl. 6, fig. 16a-c.

Shell essentially the same as described for the genus. The spire is small but elevated and the body whorl is somewhat obliquely and laterally dilated. The sculpture consists of both growth and spiral lines, the latter stronger than the former, and distinctly traceable.

Measurements of the holotype and of a paratype, in millimeters, are as follows:

Altitude of shell	7.5	7.0
Width of shell	7.0	6.0
Height of aperture	6.5	5.5
Width of aperture	5.0	4.8
Number of whorls	3	3±

Holotype: U.S.N.M. 107052, Locality 31; paratypes: U.S.N.M. 107053, Locality 31.

Family LYMNAEIDAE

Lymnaea ativuncula White

Pl. 6, fig. 17a-d.

Limnaea ativuncula White, U. S. Geol. Survey Bull. 29, p. 20, pl. 4, fig. 10, 11, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20054) consists of two specimens, both of them figured by White. This seems to be a widespread species in the Morrison formation, having been recorded from 10 localities. It is small, narrowly subfusiform in outline, and has distinct rib lines.

Figured specimen: U.S.N.M. 107039.

Lymnaea consortis White

Pl. 6, fig. 18.

Limnaea consortis White, U. S. Geol. Survey Bull. 29, p. 20, pl. 4, fig. 8–9, 1886. (Type locality: "Atlantosaurus beds," 8 miles north of Canyon City, Colorado).

The type lot (U.S.N.M. 20055) consists of 6 specimens in various stages of development. The species is *Radix*-like in having a small spire and more ventricose body whorl.

Figured specimen: U.S.N.M. 107024.

Lymnaea morrisonensis Yen, n. sp.

Pl. 6, fig. 19a-b.

Shell of moderate size, thin substance, ovately oblong outline, having a subconical and highly elevated spire and descending dilated body whorl, the spire smaller than the body whorl. Whorls increasing rapidly in size, gently convex, slightly shouldered below the suture and bearing distinct lines of growth. Aperture subovate in outline, outer lip thin and simple, parietal margin attenuated but well defined, and columella slightly twisted at its upper part, with its margin reflected and attached firmly over the umbilical area.

Measurements of the holotype and a paratype, in millimeters, are as follows:

Altitude of shell	15.0	11.0
Width of shell	8.0	5.8
Height of aperture	9.0	6.8
Width of aperture	5.0	3.8
Number of whorls	5	5

This species differs from *Lymnaea consortis* White in its larger size, more exserted and higher spire, less convex whorls and more distinctly twisted columella.

Holotype: U.S.N.M. 107025, Locality 5; paratypes: U.S.N.M. 107026 and 107041, Localities 2 and 5.

Family PLANORBIDAE

Gyraulus veternus (Meek and Hayden)

Pl. 6, fig. 20a-1.

Planorbis veternus Meek and Hayden, Smithsonian Cont. Knowl., vol. 14, no. 172, p. 107, pl. 4, fig. 1a-c, 1864 (1865). (Type locality: southwest base of Black Hills, South Dakota).

The type lot (U.S.N.M. 317) consists of a number of specimens imbedded in dark-colored limestone. They are small, none of them more than 4 millimeters in diameter. A series of specimens ranging from 2 mm (in 2½ whorls) to 7 mm (in 5 whorls), of various developmental stages are illustrated in the present work. These specimens were obtained from locality 5, north of Canyon City, Colorado.

Figured specimens: U.S.N.M. 107050.

Graptophysa spiralis Yen and Reeside

Graptophysa spiralis Yen and Reeside, Jour. Paleontology, vol. 20, p. 57, fig. 7, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

This *Physa*-like species is characterized by its spiral sculpture in combination with a fusiform outline, imperforate shell, high spire, and incised suture. It resembles *Pseudophysa grabaui* Yen in its general outline and sculpture, but it differs in its smaller size, much less convex whorls, and less pointed spire.

Family PHYSIDAE

Physa micra Yen and Reeside

Physa micra Yen and Reeside, Jour. Paleontology, vol. 20, p. 57, fig. 8, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

Physa conispira Yen and Reeside

Physa conispira Yen and Reeside, Jour. Paleontology, vol. 20, p. 57, fig. 9, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

This and *P. micra* have the features of true *Physa*, but they are much smaller than the species that have been described from Upper Cretaceous and early Tertiary beds. The only other record of *Physa* from the Morrison beds is from locality 17, where an undeterminable species of the genus was found. Its abundance at locality 37 may indicate that the exposure there represents a shallower water facies of the formation.

Aplexa morrisonana Yen and Reeside

Aplexa morrisonana Yen and Reeside, Jour. Paleontology, vol. 20, p. 58, fig. 11, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

Aplexa militaria Yen and Reeside

Aplexa militaria Yen and Reeside, Jour. Paleontology, vol. 20, p. 57, fig. 10, 1946. (Type locality: west of Mill Creek, below Lower Green River Lake, on west slope of the Wind River Mountains, Wyoming).

Although smaller, *Aplexa militaria* and *A. morrisonana* have the features of true *Aplexa*. *A. morrisonana* has more convex whorls and higher spire than *A. militaria*, though having almost the same number of whorls.

SYSTEMATIC POSITION UNCERTAIN

"Pentagoniostoma" altispiratum Branson

Pentagoniostoma altispiratum Branson, Jour. Paleontology, vol. 9, p. 520, pl. 57, fig. 1–3, 1935. (Type locality: 3 miles south of Mayoworth, Wyoming).

BIBLIOGRAPHY

ANDERSON, J. L., 1948, Cretaceous and Tertiary subsurface geology: Maryland Board Nat. Resources Bull. 2.

ARKELL, W. J., 1941, The gastropods of the Purbeck beds: Geol. Sec. London Quart. Jour., vol. 97, pp. 97–128, figs.

BAKER, A. A., 1946 [1947], Geology of the Green River Desert-Cataract Canyon region, Emery, Wayne, and Garfield Counties, Utah: U. S. Geol. Survey Bull. 951.

BAKER, A. A., DANE, C. H., and REESIDE, J. B., Jr., 1936, Correlation of the Jurassic formations of parts of Utah, Arizona, New Mexico, and Colorado: U. S. Geol. Survey Prof. Paper 183.

——— 1947, Revised correlation of Jurassic formations of parts of Utah, Arizona, New Mexico, and Colorado: Am. Assoc. Petroleum Geologists Bull., vol. 31, pp. 1664–1668.

BELL, W. A., 1946, Age of the Canadian Kootenay formation: Am. Jour. Sci., vol. 244, pp. 513-526.

BERRY, E. WILBUR, 1929, The Kootenay and Lower Blairmore floras: Canada Nat. Mus. Bull. 58, pp. 28–57.

BRANSON, C. C., 1935, Fresh-water invertebrates from the Morrison (Jurassic?) of Wyoming: Jour. Paleontology, vol. 9, pp. 514–522, 2 pls.

BROWN, R. W., 1946, Fossil plants and Jurassic-Cretaceous boundary in Montana and Alberta: Am. Assoc. Petroleum Geologists Bull., vol. 30, pp. 238–248.

——— 1950, Cretaceous plants from southwestern Colorado: U. S. Geol. Survey Prof. Paper 221–D.

BUBNOFF, SERGE VON, 1935, Geologie von Europa, Band 2, Teil 2, pp. 693-1134, 9 pls.

BURBANK, W. S., 1930, Revision of geologic structure and stratigraphy in the Ouray district of Colorado: Colorado Sci. Soc. Proc., vol. 12, pp. 151–232.

CALVERT, W. R., 1909, Geology of the Lewistown coal field, Mont.: U. S. Geol. Survey Bull. 390.

COBBAN, W. A., 1945, Marine Jurassic formations of Sweetgrass arch, Mont.: Am. Assoc. Petroleum Geologists Bull., vol. 29, pp. 1262–1303.

CROSS, WHITMAN, 1894, U. S. Geol. Survey Geol. Atlas. Pikes Peak folio (no. 7).

DARTON, N. H., 1899, Jurassic formations of Black Hills of South Dakota: Geol. Soc. America Bull., vol. 10, p. 367.

——— 1904, Comparison of the stratigraphy of the Black Hills, Bighorn Mountains, and Rocky Mountain Front Range: Geol. Soc. America, vol. 15, pp. 394–401.

DARTON, N. H., and PAIGE, SIDNEY, 1925, U. S. Geol. Survey Geol. Atlas, Central Black Hills folio (no. 219).

DUNKER, WILHELM, 1846, Monographie der norddeutschen Wealdenbildung. II. Mollusken, pp. 23–58, pls. 10–13, Braunschweig.

DUTTON, C. E., 1885, Mount Taylor and the Zuni Plateau: U. S. Geol. Survey 6th Ann. Rept., pp. 105–198.

EMMONS, S. F., CROSS, WHITMAN, and ELDRIDGE, G. H., 1896, Geology of the Denver Basin in Colorado: U. S. Geol. Survey Mon. 27.

FISCHER, C. A., 1909, Geology of the Great Falls coal field, Mont.: U. S. Geol. Survey Bull. 356.

GARDNER, L. S., HENDRICKS, T. A., HADLEY, H. D., and ROGERS, C. P., Jr., 1945, Mesozoic and Paleozoic rocks in south-central Montana: U. S. Geol. Survey Prelim. Chart 18.

GILLULY, JAMES, and REESIDE, J. B., JR., 1928, Sedimentary rocks of the San Rafael Swell and some adjacent areas in eastern Utah: U. S. Geol. Survey Prof. Paper 150–D.

GOLDMAN, M. I., and SPENCER, A. C., 1941, Correlation of Cross' La Plata sandstone, southwestern Colorado: Am. Assoc. Petroleum Geologists Bull., vol. 25, pp. 1745–1767.

GREGORY, H. E., 1917, Geology of the Navajo country—a reconnaissance of parts of Arizona, New Mexico, and Utah: U. S. Geol. Survey Prof. Paper 93.

——— 1938, The San Juan country, a geographic and geologic reconnaissance of southeastern Utah: U. S. Geol. Survey Prof. Paper 188.

HADLEY, H. D., GARDNER, L. S., and ROGERS, C. P., JR., 1945, Graphic sections of Mesozoic and Paleozoic rocks that underlie the basin areas in south-central Montana: U. S. Geol. Survey Prelim. Chart 19.

HOLT, E. L., 1942, A new *Unio* from the Morrison formation of Grand River Valley, Colo.: Jour. Paleontology, vol. 16, pp. 459–460, 1 pl.

HUDDLE, J. W., and MCCANN, F. T., 1947, Geologic map of the Duchesne River area, Wasatch and Duchesne Counties, Utah: U. S. Geol. Survey Prelim. Map 75.

IMLAY, R. W., 1947, Marine Jurassic of Black Hills area, S. Dak. and Wyo.: Am. Assoc. Petroleum Geologists Bull., vol. 31, pp. 227–273.

KOCH, FR. C. L., and DUNKER, WILHELM, 1837, Beitraege zue Kenntniss des morddeutschen Oolithgebirges and dessen Versteinerungen, Braunschweig.

LEE, W. T., 1920, Type section of the Morrison formation: Am. Jour. Sci., 4th ser., vol. 49, pp. 183–188.

——— 1927, Correlation of geologic formations between east-central Colorado, central Wyoming, and southern Montana: U. S. Geol. Survey Prof. Paper 149.

LOGAN, W. N., 1900, The stratigraphy and invetebrate faunas of the Jurassic formation in the Freeze-out Hills of Wyoming: Kansas Univ. Quart., vol. 9, pp. 109–134, 7 pls.

LOVE, J. D., and others, 1945, Stratigraphic sections and thickness maps of Lower Cretaceous and nonmarine Jurassic rocks of central Wyoming: U. S. Geol. Survey Preliminary Chart 13.

——— 1947, Stratigraphic sections of Mesozoic rocks in central Wyoming: Wyoming Geol. Survey Bull. 38.

MAILLARD, GUSTAVE, 1884, 1886, Invertebres du Purbeckien du Jura: Mem. Soc. paleont. Suisse, tome 11; Supplement, tome 12.

MANSFIELD, G. R., 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152.

MEEK, F. B., 1861, Descriptions of new Lower Silurian (Primordial), Jurassic, Cretaceous, and Tertiary fossils, collected in Nebraska: Acam. Nat. Sci. Philadelphia Proc., vol. 13, pp. 415–447.

——— 1865, Paleontology of the Upper Missouri. Invertebrates: Smithsonian Contr. Knowledge, vol. 14, art. 5.

MEEK, F. B., and HAYDEN, F. V., 1858, Descriptions of new organic remains collected in Nebraska Territory in the year 1857: Acad. Nat. Sci. Philadelphia Proc., vol. 10, pp. 41–59.

MOOK, C. C., 1916, A study of the Morrison formation: New York Acad. Sci. Annals, vol. 27, pp. 39–191.

PECK, R. E., 1937, Morrison Charophyta from Wyoming: Jour. Paleontology, vol. 11, pp. 83–90.

——— 1941, Lower Cretaceous Rocky Mountain nonmarine microfossils: Jour. Paleontology, vol. 15, pp. 285–304.

PIERCE, W. G., and ANDREWS, D. A., 1941, Geology and oil and coal resources of the region south of Cody, Park County, Wyo.: U. S. Geol. Survey Bull. 921–B.

REESIDE, JOHN B., JR., 1931, Supposed marine Jurassic (Sundance) in foothills of Front Range of Colorado: Am. Assoc. Petroleum Geologists Bull., vol. 15, pp. 1095–1103.

RICHMOND, G. M., 1945, Geology and oil possibilities at the northwest end of the Wind River Mountains, Sublette County, Wyo.: U. S. Geol. Survey Prelim. Map 31.

ROBINSON, W. I., 1915, Two new fresh-water gastropods from the Mesozoic of Arizona; Am. Jour. Sci., 4th ser., vol. 40, pp. 649–651, text figs.

ROEMER, F. A., 1835–1836, Die Versteinerungen des norddeutschen Oolithengebirges, Hannover.

ROTH, ROBERT, 1933, Some Morrison Ostracoda: Jour. Paleontology, vol. 7, pp. 398–405, 1 pl.

SANDBERGER, FR. C. L., 1870–1875, Die Land – und Suesswasser – Conchylien der Vorwelt, Wiesbaden.

SOWERBY, J. DE C., 1813-1936, Mineral conchology of Great Britain.

STANTON, T. W., 1909, Succession and distribution of later Mesozoic invertebrate faunas in North America: Jour. Geology, vol. 17, pp. 410–423.

——— 1915, Invertebrate fauna of the Morrison formation: Geol. Soc. America Bull., vol. 26, pp. 343–348.

STOKES, W. L., 1944, Morrison formation and related deposits in and adjacent to the Colorado Plateau: Geol. Soc. America Bull., vol. 55, pp. 951–992.

STOKES, W. L., and PHOENIX, D. A., 1948, Geology of the Egnar-Gypsum Valley area, San Miguel and Montrose Counties, Colo.; U. S. Geol. Survey Prelim. Map 93.

STRUCKMANN, C. E. F., 1880, Die Wealden-Bildungen der Umgegend von Hannover, Hannover.

THOM, W. T., JR., and others, 1935, Geology of Big Horn County and the Crow Indian Reservation, Mont.: U. S. Geol. Survey Bull. 856.

UNTERMANN, G. E. and UNTERMANN, B. R., 1949, Geology of Green and Yampa River Canyons and vicinity, Dinosaur National Monument, Utah and Colorado: Am. Assoc. Petroleum Geologists Bull., vol. 33, pp. 683–694.

VEATCH, A. C., 1907, Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: U. S. Geol. Survey Prof. Paper 56.

WALDSCHMIDT, W. A., and LEROY, L. W., 1944, Reconsideration of the Morrison formation in the type area, Jefferson County, Colo.: Geol. Soc. America Bull., vol. 55, pp. 1097–1114.

WHITE, C. A., 1878, Paleontological papers No. 6: Descriptions of new species of invertebrate fossils from the Laramie group: U. S. Geol. and Geog. Survey Terr. Bull., vol. 4, pp. 707–719.

——— 1886, On the fresh-water invertebrates of the North American Jurassic: U. S. Geol. Survey Bull. 29.

WIELAND, G. R., 1906, American fossil cycads: Carnegie Inst. Washington Pub. 34, 266 pp., 50 pls., 137 figs.

WOOD, S. V., 1842, A catalogue of shells from the Crag: Annals and Mag. Nat. History, vol. 9, pp. 527–544.

YEN, T.-C., 1946, On Lower Cretaceous fresh-water mollusks of Sage Creek, Wyo.: Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166.

YEN, T.-C. and REESIDE, J. B., JR,. 1946, Fresh-water mollusks from the Morrison formation (Jurassic) of Sublette County, Wyo.: Jour. Paleontology, vol. 20, pp. 52–58, text figs.

———1946, Triassic freshwater gastropods from southern Utah: Am. Jour. Sci., vol. 244, pp. 49–51, 1 pl.

INDEX

Italic numbers indicate descriptions.

J

K

L

M

N

O

P

R

S

☆ U. S. GOVERNMENT PRINTING OFFICE: 52—953164

PLATES 3–6

PLATE 3

Figures 1a–c. *Unio felchi* White ×1, locality 3. (p. 35)

2. *Unio baileyi* Logan ×1, locality 31. (p. 35)

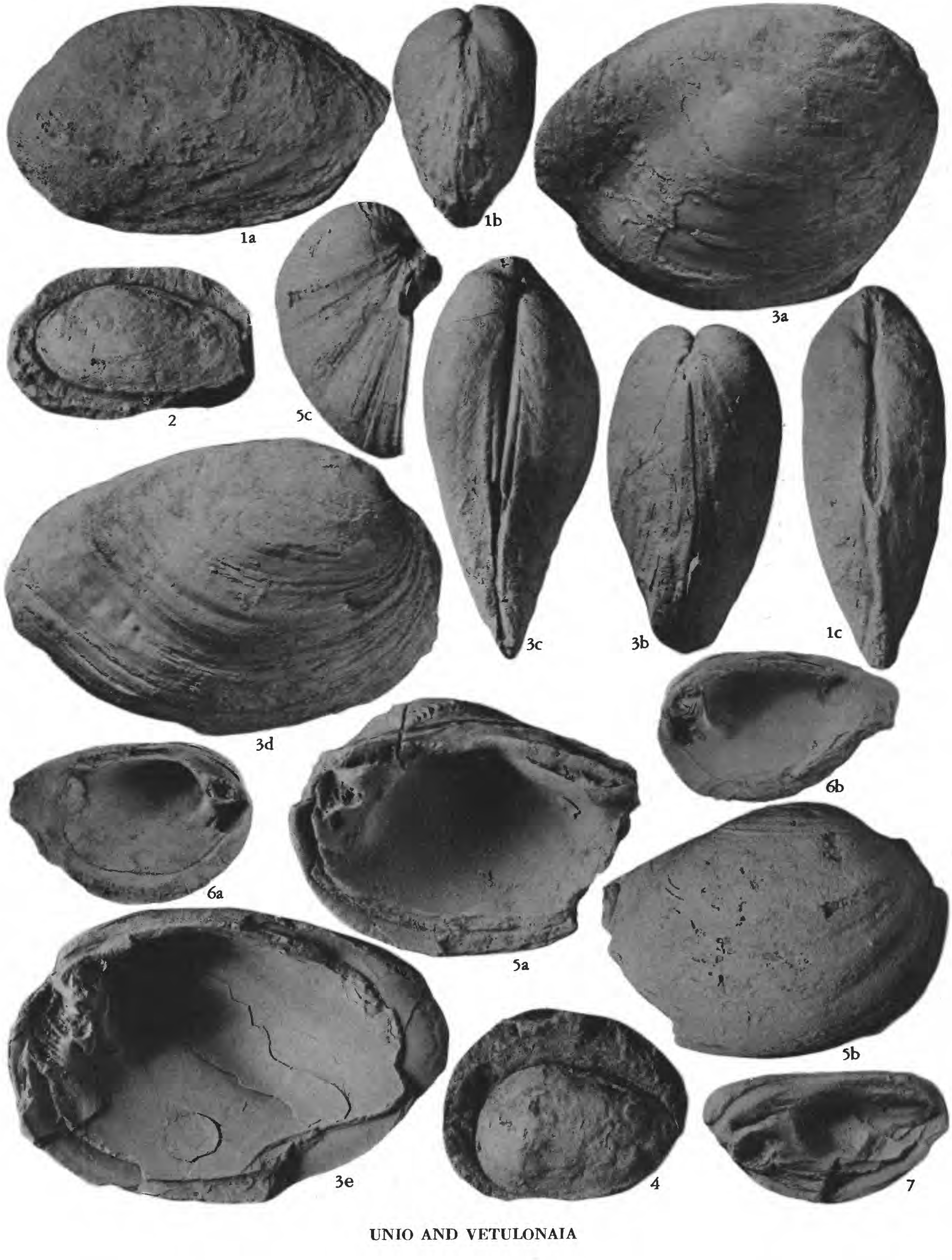
3a–e. *Unio stewardi utahensis* Yen ×1, locality 23. (p. 36)

4. *Unio willistoni* Logan ×1, locality 31. (p. 36)

5a–c. *Unio nucalis* Meek and Hayden ×2, locality 35. (p. 36)

6a–b. *Vetulonaia whitei* Branson ×1, re-illustrations of the holotype from the Museum of the University of Missouri through courtesy of Prof. E. B. Branson. (p. 37)

7. *Vetulonaia mayoworthensis* Branson ×1, re-illustration of the holotype from the Museum of the University of Missouri through courtesy of Prof. E. B. Branson. (p. 37)



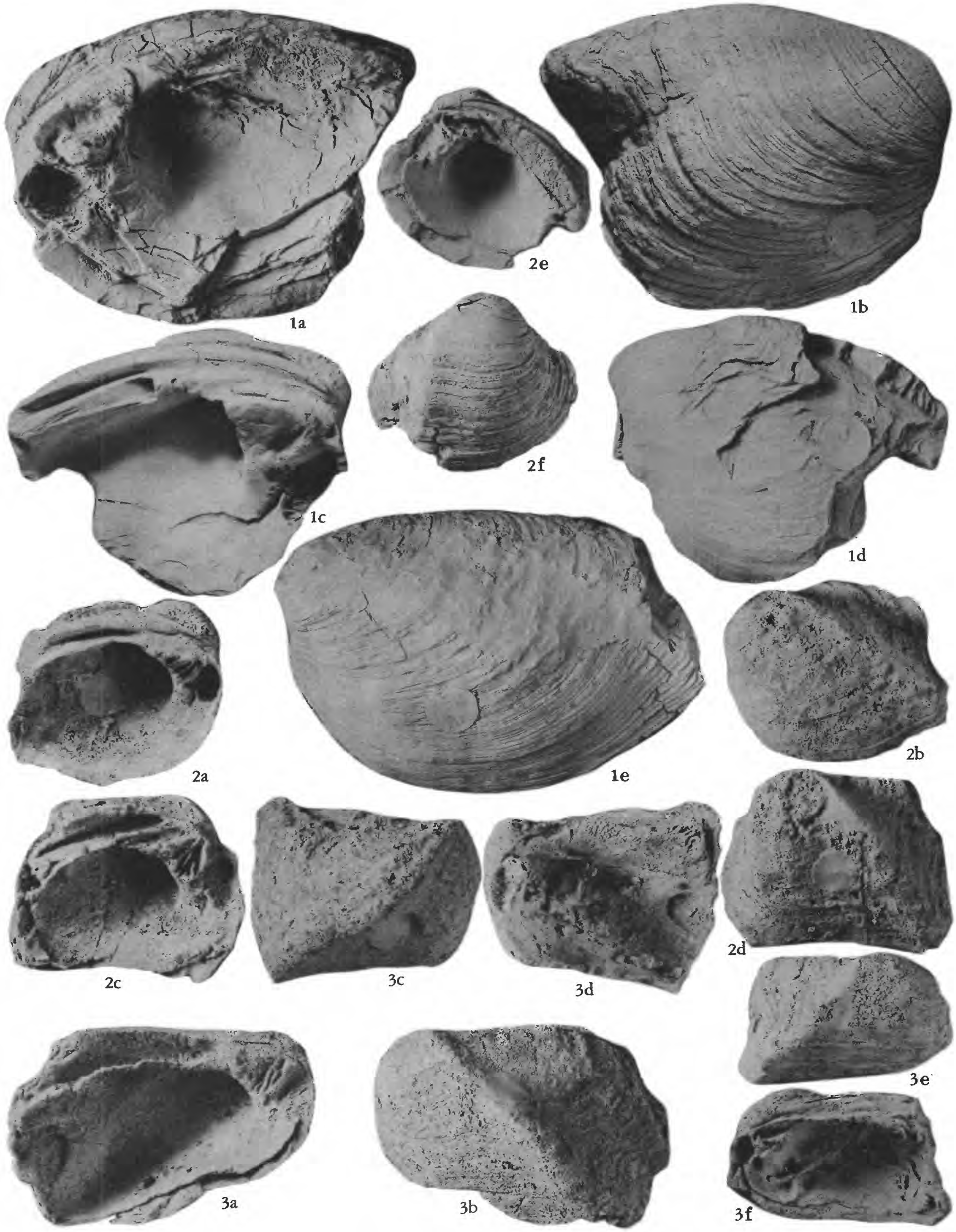
UNIO AND VETULONAIA

PLATE 4

Figures 1a–e. *Unio mammilaris* Yen ×1, a-d, paratypes, locality 40; e, holotype, locality 39. (p. 36)

2a–f. *Hadrodon jurassicus* Yen ×1, a-b, holotype; c-d, paratypes, locality 7; e-f, paratypes; locality 10. (p. 37)

3a–f. *Hadrodon trigonus* Yen ×1, a-b, holotype; c-f, paratypes, locality 7. (p.38)



UNIO AND HADRODON

PLATE 5

Figures 1a–d. *Hadrodon trigonus* Yen, ×1, paratypes, locality 7. (p. 38)

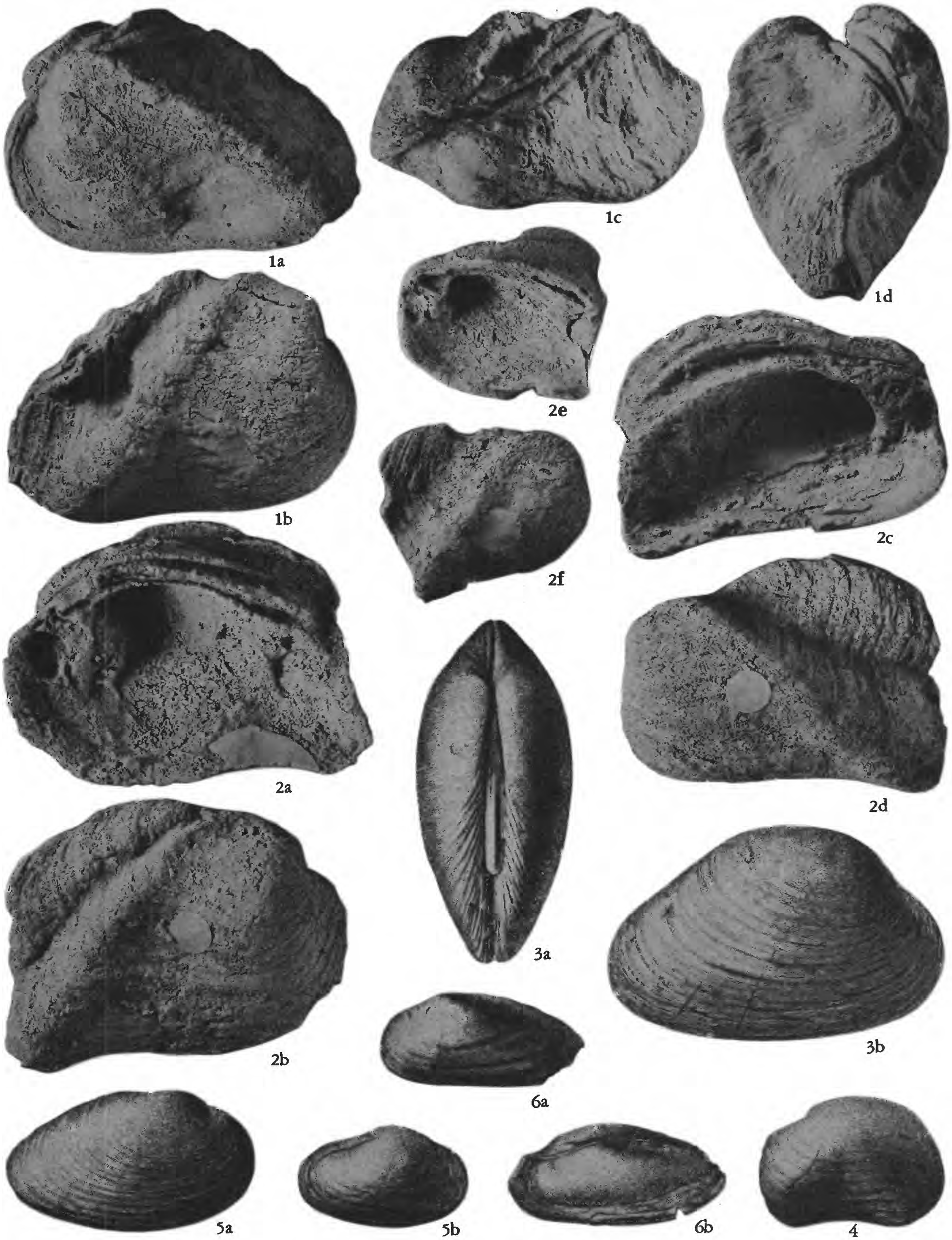
2a–f. *Hadrodon lateralis* Yen, ×1, a-b, holotype; c-f, paratypes, locality 7. (p. 38)

3a–b. *Unio taxonotus* White, ×1, (after White), locality 4. (p.35)

4. *Unio macropisthus* White, ×1, (after White), locality 4. (p. 35)

5a–b. *Unio iridoides* White, ×1, (after White), locality 4. (p. 35)

6a–b. *Unio lapilloides* White, ×1, (after White), locality 4. (p.35)



UNIO AND HADRODON

PLATE 6

Figures 1a–f. *Amplovalvata cyclostoma* Yen, ×2, a–c holotype; d-f, paratype, locality 5. (p. 39)

2a–o. *Amplovalvata scabrida* (Meek and Hayden), ×2, a–c, locality 22; d-f, m-o, locality 10; g-i, locality 23; i-l, locality 29. (p. 39)

3a–c. *Amplovalvata scabrida leei* (Logan), ×2, locality 31. (p. 40)

4a–c. *Tropidina jurassica* (Branson), ×2, locality 33. (p. 40)

5a–c. *Liratina jurassica* (Branson), ×4, locality 33. (p. 40)

6a–e. *Viviparus reesidei* Yen, ×2. a, holotype; b-c, paratypes; c, young forms of the species imbedded in rock. Locality 11. (p. 40)

7a–d. *Viviparus morrisonensis* Yen, ×1, a-b, holotype, locality 1; c-d, paratype, locality 29. (p. 41)

8a–b. *Lioplacodes jurassicus* Yen, ×2, holotype, locality 31. (p. 41)

9. *Amnicola gilloides* Yen and Reeside, ×2, locality 33. (p. 41)

10a–b. *Amnicola jurassica* Yen, ×2, a, holotype; b, paratype, locality 23.

10c. *Amnicola* sp. undet., ×2, lcoality 8. (p. 41)

11a–f. *Mesoneritina morrisonensis* Yen, ×2, a-c, holotype, locality 10; d-f, paratype, locality 23. (p. 42)

12a–b. *Mesauriculstra accelerata* (White), ×2, locality 5. (p. 42)

13a–b. *Mesauriculstra morrisonensis* Yen, ×2, a. holotype; b, paratype, locality 5. (p. 43)

14a–d. *Mesauriculstra morrisonensis ovalis* Yen, ×2, a, holotype; b-d, paratypes, locality 5. (p. 43)

15a–b. *Mesochilina spiralis* Yen, ×2, a, holotype; b, paratype, locality 20. (p. 43)

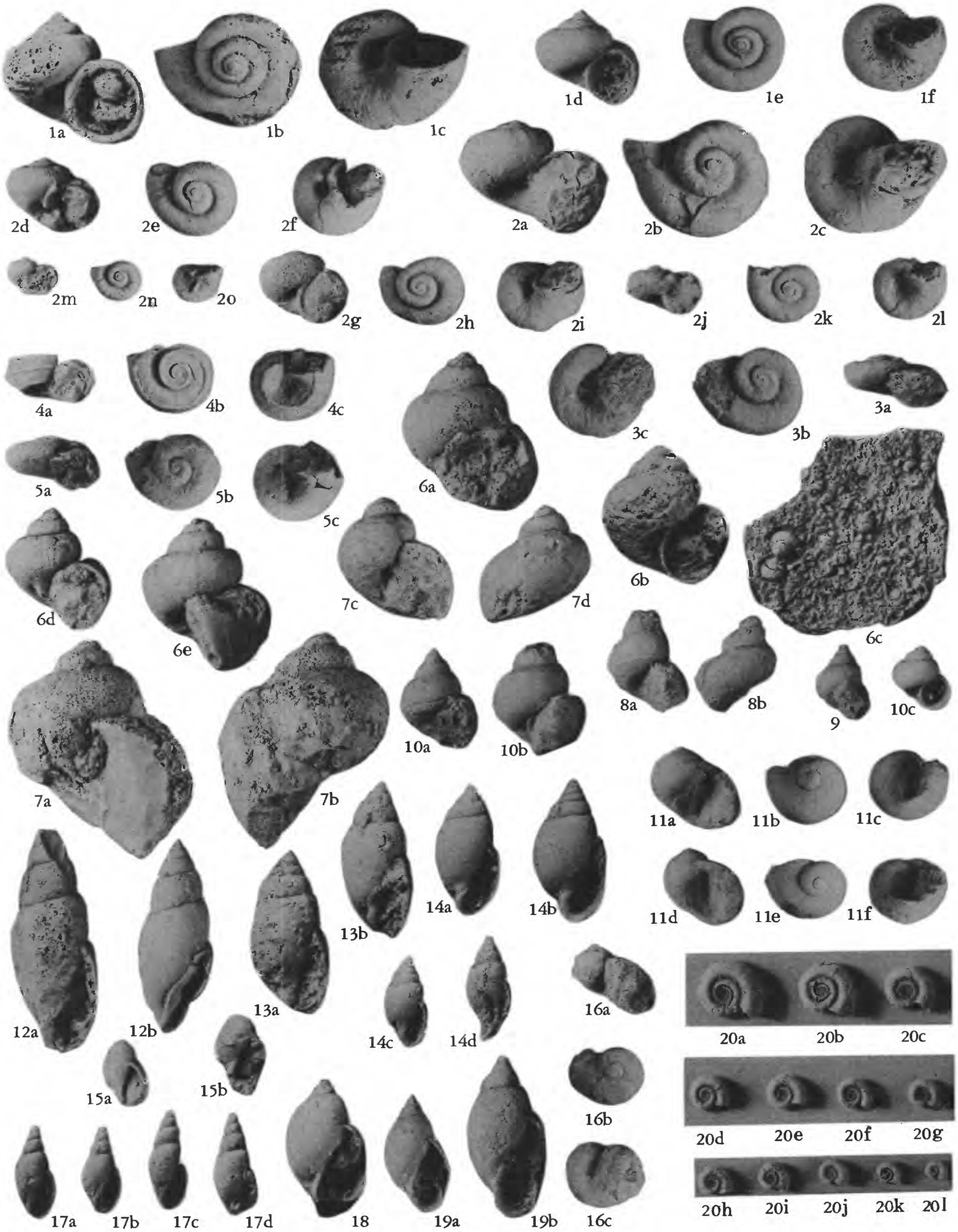
16a–c. *Limnopsis jurassica* Yen, ×2, holotype, locality 31. (p. 44)

17a–d. *Lymnaea ativuncula* White, ×4, locality 5. (p. 44)

18. *Lymnaea consortis* White, ×2, locality 5. (p. 44)

19a–b *Lymnaea morrisonensis* Yen, ×2, a, paratype; b, holotype, locality 5. (p. 44)

20a–l. *Gyraulus veternus* Meek and Hayden, ×2, locality 5. Showing developmental stages. (p. 44)


1a
1b
1c
1d
1e
1f
2d
2e
2f
2a
2b
2c
2m
2n
2o
2g
2h
2i
2j
2k
2l
4a
4b
4c
3c
3b
3a
5a
5b
5c
6a
6b
6c
6d
6e
7c
7d
7a
7b
10a
10b
8a
8b
9
10c
11a
11b
11c
11d
11e
11f
12a
12b
13a
13b
14a
14b
14c
14d
16a
16b
16c
15a
15b
17a
17b
17c
17d
18
19a
19b
20a
20b
20c
20d
20e
20f
20g
20h
20i
20j
20k
20l

GASTROPODA