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ON THE

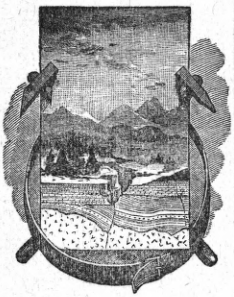
FRESH-WATER INVERTEBRATES

OF THE

NORTH AMERICAN JURASSIC

BY

CHARLES A. WHITE, M. D.



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CONTENTS.

ILLUSTRATIONS.

FRESH-WATER INVERTEBRATES OF THE NORTH AMERICAN JURASSIC.

By CHARLES A. WHITE.

I. GENERAL REMARKS.

Important additions having lately been made to our knowledge of the fresh-water invertebrates of the North American Jurassic strata, I have thought it desirable to present not only descriptions and figures of the new forms in this bulletin, but to make the publication an illustrated synopsis of all the forms yet discovered. I therefore reproduce on the accompanying plates figures of all the species hitherto published, in addition to those of the new forms. Besides this, I offer the following general discussion of the subject of those fresh-water fossils and their bearing upon continental history.

Among the earliest collections of fossils made from the Jurassic rocks of North America, Meek and Hayden recognized certain of the species as belonging to such fresh-water genera as *Unio*, *Viviparus*, *Lioplacodes*. *Planorbis*, and *Valvata*.[1]

The specimens referred to these genera were collected by Dr. Hayden in the region of the Black Hills of Dakota, and, although he felt quite sure that they came from Jurassic strata, the rock specimens which contained the fossils were detached from their original ledges, and no rediscovery of the species in situ has since been made unless some of the forms described in this bulletin shall prove to be identical. Subsequently I described a species of *Unio* from some fragments which were discovered in Jurassic strata near the banks of Green River, Wyoming, by Mr. J. F. Steward, a member of an exploring party then in charge of the present Director of the U. S. Geological Survey.[2] Still later, I republished with figures all the species which have just been referred to.[3] Besides these fossils, which were published by Meek and Hayden and myself, respectively, no fresh-water invertebrate fossils have hitherto

[1] Palæontology of the Upper Missouri, Meek and Hayden; Smithsonian Contributions, 1864.

[2] Report on the Geology of the Uinta Mountains, J. W. Powell, p. 10.

[3] Review of the Non-Marine Fossil Mollusca of North America, Third Annual Report of the U. S. Geological Survey, p. 426, Pl. 3.

been publicly announced as coming from the Jurassic strata of North America.

I have no reason to doubt that the five species which were published by Meek and Hayden really came from Jurassic strata; but, even if it should hereafter appear that they are of later age, the following remarks in relation to our fresh-water Jurassic fauna are warranted by our present knowledge of species which come from strata the Jurassic age of which is known.

No division of the Jurassic strata of Western North America into an upper and a lower series has been suggested upon paleontological grounds by those who have written upon the invertebrate fossils which they are found to contain. Professor Marsh was the first to divide those strata paleontologically, which he did in consequence of the marked difference he found to exist between the vertebrate fossils that characterize the upper and the lower series respectively. It is probable, however, that when our Jurassic invertebrates come to be fully known, those upper and lower divisions respectively will be found to show a corresponding difference. There is also a lithological difference between the strata of the two divisions, which, while it is not pronounced, is usually more or less distinctly recognizable.

In an article which I lately published[1] I remarked that no invertebrate fossils, so far as I was aware, had up to that time been found in the upper or Atlantosaurus division of the Jurassic. That remark would have been more nearly correct if it had contained the statement that no invertebrate fossils had been published as coming from that division of the Jurassic; and I was soon afterward reminded of this technical error by a letter from Professor Marsh. He then also informed me that his collectors frequently met with fresh-water molluscan forms while quarrying for vertebrate fossils in the Atlantosaurus beds, and at the same time he sent me some Uniones and a small gasteropod. A part of these fossils had been obtained from his Jurassic quarries at Como, Wyo., and a part of them from those near Cañon City, Colo., all of them coming from the Atlantosaurus beds.

The inference being a natural one that these few forms were members of a contemporaneous fauna which embraced a considerable number of other species, I visited the quarries, in both Colorado and Wyoming, from which they were obtained, for the purpose of personal observation and collection, and I was rewarded by the discovery of several additional species at the Colorado locality, which, together with others, are described and figured in this bulletin. By the aid of Mr. M. P. Felch, who for several years past, under the direction of Professor Marsh, has obtained from the Jurassic rocks near Cañon City such remarkable collections of dinosaurian and other vertebrate remains, I was able to determine accurately the horizon of the invertebrates with relation to

[1] American Journal of Science, Vol. XXIX (3), p. 228.

that of the vertebrates. In fact I found them both to occupy the same horizon, the layers bearing the invertebrates alternating with those bearing the vertebrates, some of the species of the former ranging through several of the layers. A portion of the specimens of *Unio* contained in the collections which were made near Cañon City were found in a layer immediately above the uppermost one in which dinosaurian remains have yet been found there; but other specimens of the same species were found beneath that layer, associated with the gasteropods, showing that even the species referred to began its existence before the extinction of the Jurassic dinosaurs. The other species, including all the gasteropods, were found beneath a greater or less number of layers bearing dinosaurian remains. In short, the observed conditions were such as to leave no room for doubt that the vertebrate and invertebrate faunas whose remains are found there lived contemporaneously. This statement is emphasized here because these fresh-water invertebrate species of Jurassic age are so modern in type that of themselves they offer no suggestion of greater age than the Tertiary.

The horizon of the fresh-water Jurassic mollusca which were found at Como, Wyo., was pointed out to me with equal precision by Mr. Kennedy, who has for many years collected vertebrate fossils there for Professor Marsh, and their position in the Atlantosaurus beds was ascertained beyond question by my personal observation.

Several years ago I also visited the locality from which Mr. Steward obtained the fragments of *Unio* referred to in a previous paragraph, and, although I was not able to make any further discoveries there, nor to determine with precision the layer from which Mr. Steward obtained his specimens, I believe them to have come from the equivalent of the Atlantosaurus beds. I have never visited the locality in the region of the Black Hills from which Dr. Hayden obtained his Jurassic fossils, and I have therefore no certain information as to whether they came from the Atlantosaurus beds or not.

The apparent identity of one or two of those species from the Black Hills with some which were found at the Cañon City locality, and of one or two of the species from the latter locality with some of those at Como, suggests an identity of horizon at the three localities; but, even if the identity referred to is real, the horizon of each locality may be more or less different, for it is believed that some of the species then existing may have passed from one horizon to another, even as certain fresh-water species are now known to have passed from the Laramie up into the Wasatch group. The character of the strata in which these fresh-water Jurassic fossils were found, both at the Colorado and at the Wyoming localities, in addition to the character of the fossils themselves, is such as to indicate for them a lacustrine, and not an estuary or a fluviatile, origin; that is, the rocks are regularly stratified and have such an aspect and character as to indicate that they were deposited in one or more large bodies of water. If the strata of the Colo-

rado and of the Wyoming localities really contain an identical fauna, it may be regarded as at least probable that they were deposited in one and the same lake. The distance between the Colorado and the Wyoming localities indicates that the supposed lake was nearly 200 miles across; and, if the Black Hills fossils also belonged to the same contemporaneous fauna, the assumed lake was much larger. The existence of a fresh-water lake of even the smaller size suggested makes it necessary to infer that there was then in that part of the North America of to-day a continental area of considerable size, for such a lake could hardly be other than a part of a large drainage system. But, aside from these considerations, the existence of such fresh-water faunas as are represented by these collections, whether in large or in small bodies of water, indicates with hardly less clearness than the proved existence of one great lake would do the synchronous existence of a large continental area. Indeed it seems necessary to assume that in the fresh waters of a large land area alone could faunas of such a character as those which are represented by these collections be developed and perpetuated.

The inference that there was during the Jurassic period a great North American land area, which seems to be so fully warranted by the presence in those strata of the fresh-water invertebrates which are illustrated on the plates of this bulletin, is supported with equal force by the evidence which is afforded by the large collections of vertebrate remains that have been brought out by Professor Marsh. These show that there existed then a large proportion of vegetable feeders and other land denizens among the widely differentiated dinosaurs, besides a not inconsiderable mammalian fauna.

The belief has prevailed among geologists that the great interior portion of the present continent of North America, now occupied by Mesozoic and later strata was, until the close of the Cretaceous period, continuously occupied by an oceanic belt which separated a large western from a large eastern continental area. That portions of this assumed intercontinental marine area were really occupied by marine waters at different times during the Paleozoic and Mesozoic ages cannot be doubted, because of the marine character of the deposits which are found there. The facts which have just been stated with reference to Jurassic faunas, however, plainly indicate that a large part of that area was above the sea during the Jurassic period.

There are other facts which indicate that the great interior region in question was the scene of extensive shiftings of land and sea during the whole of Mesozoic time, and until its final incorporation with adjacent areas to form the present North American continent. Reference is here made to the breaks or omissions in the order of succession of the formations which are now found upon either side of that portion of the region in question, which lies between the thirty-eighth and the forty-fourth parallels, the omitted formations being absent over extensive areas. If

we go to the western or Rocky Mountain portion of this great interior region, we find the Triassic rocks resting upon the Carboniferous, and the Jurassic and the Cretaceous formations following them in their order, the strata of all three of these periods being there more or less fully developed. Coming then to the eastern side, to the region of the ninety-sixth meridian, or that which is traversed by the middle portion of the Missouri River, we find the lowest member of the Cretaceous resting directly upon the Carboniferous, the Triassic and the Jurassic being absent in all that region.

The intervening space between that region and the eastern base of the Rocky Mountains is occupied by the Great Plains and the prairie region with which they blend to the eastward; in all, some six or eight degrees of longitude in width. No natural exposures of either Jurassic or Triassic strata have been found upon either the Great Plains or the prairies. Still, it is clear that these two formations extend for some distance to the eastward beneath the plains, because they are so conspicuously present at their western border, the foot of the mountains.

The only positive knowledge we have yet obtained as to the existence of those strata beneath the plains is derived from an artesian boring made by order of the United States Agricultural Department, at Fort Lyon, Colo.[1] This locality is about one-third of the distance across the plains proper, eastward from their western border, the base of the Rocky Mountains. At Fort Lyon the boring passed first through the lower member of the Cretaceous, then through the Jurassic and into the Triassic. The Jurassic strata there have less than half the thickness which they reach in the Rocky Mountain region. This shows so rapid a thinning of that formation to the eastward that its eastern border is probably only a few miles farther eastward than the Fort Lyon boring. How far the Triassic extends eastward beneath the Great Plains is not known, but probably not farther than does the Jurassic. The Cretaceous rocks are doubtless continuous beneath the whole surface of the plains, for they have been found exposed at the surface at several points upon them, and also at many points farther eastward, in Kansas and Nebraska. They are also known to exist in Iowa, not only in the western part of the State, but in the northern and northeastern portions also, as well as in adjoining parts of Minnesota and Dakota.

The facts thus presented indicate remarkable westward advances and eastward recedences of the western coast line of the eastern continental area during Mesozoic time. These movements were remarkable for their great geographical extent in both directions, for the slight evidence of littoral action which the strata present, for the comparatively slight vertical extent of the movements, and for the absence of evidence of any correlated orologic displacements. It is not asserted that a definite history of these sea-border movements has been ascertained,

[1] Artesian Wells upon the Great Plains. Department of Agriculture: pamphlet, pp. 38 and geological map. Washington, Government Printing Office, 1882.

but the following suggestions seem to be warranted by the stratigraphical conditions which are known to exist now, a part of which has just been mentioned. At the close of the Carboniferous age there was a great westward extension of the eastern continental area, and during the Triassic and Jurassic periods that area had extended its western border to near the one hundred and third meridian. Immediately upon the close of the Jurassic and at the beginning of the Dakota epoch of the Cretaceous, that border retreated eastward, so that parts of it at least reached as far eastward as the ninety-fifth meridian. A little later, in the Colorado epoch of the Cretaceous, the maximum eastward extension of the Cretaceous sea occurred, which carried a portion of it as far eastward as the ninety-third meridian, in what is now the northeastern portion of Iowa and the southeastern portion of Minnesota. Before the close of the Colorado epoch a rapid retreat to the westward of the Cretaceous sea border was begun, and by the close of that epoch it seems to have reached as far westward as about the one hundredth meridian. At the close of the Fox Hills epoch of the Cretaceous, at least a very large part of the area which was then occupied by marine waters became the seat of the great inland Laramie sea, and true marine waters then finally disappeared from the interior of the present continent.

It is true that the evidence as to the nature and extent of these alternate eastward and westward movements of oceanic and continental borders is not so complete as could be desired, but it is believed that the considerations which have just been presented are fully justified by the stratigraphical conditions referred to, and that their correctness will not be doubted by geologists who may have observed those conditions. That a large part of that interior region, together with other portions of the present continent, was above the level of the sea during the Jurassic period, especially in the latter part of it, seems to be equally certain. Indeed, in view of the evidence we have (derived from both the vertebrate and invertebrate fossils mentioned in preceding paragraphs) of the existing continental conditions and in view of the limited extent of recognized marine Jurassic deposits in North America and the doubtful age of some of the deposits which have been referred to that period, one cannot say with confidence that any considerable part of the present North American continent was beneath the sea during any portion of the Jurassic period. In conclusion, I think it may be safely assumed that the great inland portion of our continent was not so permanently the seat of oceanic waters during Mesozoic time as has been supposed.

II. DESCRIPTION AND CITATION OF SPECIES.

Descriptions of the new species which have lately been obtained from Colorado and Wyoming are given upon following pages, accompanying which are citations with remarks upon all the other fresh-water inverte-

brates hitherto published from the Jurassic rocks of North America. The object in presenting the previously published forms together with the new is, as before remarked, to give a synopsis of all the known fresh-water fossils which have been discovered in our Jurassic rocks.

It is to be expected that other forms will yet be discovered, because the Jurassic deposits which are now known to be of fresh-water origin are quite extensive, and also because the forms which are at present known almost certainly do not constitute a complete fauna. So large a proportion of the discovered species belong to types that are common among living faunas that we naturally look for such other types among the fossil species as are usually associated with their living congeners. For example, having two typical species of *Limnæa*, we expect to find *Physa* associated with them; and, having the palustral pulmonates so well represented, we naturally expect to find representatives of the land pulmonates also. Besides the forementioned types which these Jurassic collections embrace, the somewhat numerous examples of Unionidæ and Viviparidæ among them add still further to their modern aspect. Indeed, so modern is the facies of the Jurassic fauna, as represented by the collections here discussed, that one is surprised to find only a single type among them which is not common among American living fresh-water species, and this type is referred to the Limnæidæ. Still, in view of the great age of these fossils, it may be expected that some types will yet be found which living faunas do not contain.

MOLLUSCA.

UNIONIDÆ.

All the species of the Unionidæ which have been found in the Jurassic rocks of North America, the hinge characters of which have been seen, belong to the genus *Unio* proper; and all the others doubtless possess the same generic characters. They also all belong to the simpler types of that genus as regards their outward shape; and all of them have the surface plain or without wrinkles, tubercles, or other ornamentation except the ordinary lines of growth. Most of them depart but little from the transversely oval shape which is so common among both living and fossil species, and none of them possess features which separate them, except specifically, from numerous known Tertiary and living forms. The rugose and tubercular ornamentation, such as is common among the living Uniones of the Mississippi River system, has not been observed upon any members of the family of earlier date than the Laramie period. I have elsewhere expressed the opinion that the Unione fauna of the Laramie group are ancestrally related to the living Unione fauna of the Mississippi River system, and that the genetic line of descent was

preserved through the persistence of rivers during succeeding geological epochs.[1]

It is not improbable that the genetic relationship of the living and of the Laramie Uniones extends back to the Jurassic period, and that it includes those which are herein described and figured. None of these Jurassic Uniones, however, have features which distinguish them as to type from plain forms, both living and fossil, which are found in various other parts of the world, while a considerable part of the Laramie species are of distinctively North American types.

UNIO FELCHII (sp. nov.).

Plate I, Figs. 1, 2, 3, 4, and 5.

Shell transversely elongate, suboval in marginal outline, short and somewhat narrow in front of the beaks, higher behind them, elongate and narrowing towards the posterior end; basal margin gently convex or nearly straight, and usually a little emarginate just behind the mid-length of the shell; front margin regularly but somewhat narrowly rounded; dorsal margin long behind the beaks and broadly convex from the beaks to the posterior end, short in front of the beaks, declining to the anterior end; posterior margin narrowly and regularly rounded; beaks situated near the front, depressed so that the greatest height of the shell is a little behind them; umbones somewhat broad; umbonal ridges not defined; valves moderately convex; surface plain; ligament long and prominent.

Length of an adult example, but not quite the largest in the collection, 80 millimeters; height, 44 millimeters; convexity, both valves together, 20 millimeters. Some of the examples which were found associated with the typical adult forms are more nearly oval in outline, but they are regarded as the young of this species.

This species belongs to one of the plain types of the Unionidæ which prevails among both fossil and recent forms. The type to which it belongs also embraces *U. clinopisthus* White, from the Green River Eocene group of Southern Wyoming, the living *U. gibbosus* Barnes, &c. Indeed, if it were not for the known horizon from which this species comes and its association with dinosaurian remains, one could not say with certainty that it is of earlier date than the Tertiary. A considerable number of specimens of this species have been collected, and it seems to have lived in great abundance. The specific name is given in honor of Edward Felch, the young man who first discovered this species, together with the following one.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo., where it is associated with the following species and with all the gasteropods which are herein described from that locality.

[1] Review of the Non-Marine Fossil Mollusca of North America, C. A. White, p. 78.

UNIO TOXONOTUS (sp. nov.).

Plate II, Figs. 1 and 2.

Shell suboval in marginal outline, short and narrow in front of the beaks, elevated and convex behind them, where the shell has its greatest height, narrowing rapidly towards the posterior end; basal margin broadly convex; front and posterior margins narrowly rounded; dorsal margin strongly convex, sloping abruptly downward both before and behind; beaks depressed, situated near the front; umbones broad; the sides of the valves having the ordinary convexity, but the dorsal border of each is so much inflexed in adult examples as to hide the ligament from side view. Surface plain, being marked only by the ordinary lines of growth.

Length, 60 millimeters; height, 39 millimeters; convexity, both valves together, 28 millimeters.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo., where it is associated with the preceding species.

UNIO MACROPISTHUS (sp. nov.).

Plate II, Fig. 7.

Shell rather small, irregularly oblong in marginal outline, the front portion being conspicuously narrower than the posterior portion; basal margin broadly emarginate; front margin rounded from the base to the short antero-dorsal margin; postero-dorsal margin somewhat regularly rounded from the beaks to the postero-basal margin, which is more narrowly rounded to the base; beaks not prominent, situated subcentrally, or a little nearer to the front than to the posterior end; valves somewhat irregularly convex, the median portion being flattened or compressed at the base. Surface plain, being marked only by the ordinary lines of growth.

Length of the most perfect example obtained, 33 millimeters; height behind the beaks, 24 millimeters.

The specimens which are referred to this species were found only in a layer of soft sandy shale, and only in the condition of natural casts. One of these specimens shows the general features of the interior of the shell, and others show its external form. The specimens are imperfect, but the more important features of the shell are so well preserved that it is referred to a distinct species with much confidence.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo.

UNIO IRIDOIDES (sp. nov.).

Plate II, Figs. 3 and 4.

Shell rather small, moderately elongate transversely, subelliptical in marginal outline; valves somewhat regularly convex; beaks small, not prominent, situated at a little more than one-quarter of the length of

the shell from the front; basal margin broadly convex; front margin regularly rounded; dorsal margin proper comparatively short; postero-dorsal margin longer and sloping downward to the posterior end. Surface plain.

Length of the largest example in the collection, 45 millimeters; height, 27 millimeters.

Some natural casts of this species were found in the layer of soft sandy shale associated with the preceding species and also the two following ones; but the largest example, which is figured on Plate II, was obtained from a higher layer, where it is associated with *U. Felchii* and *U. toxonotus*. This larger example has the natural surface preserved, and in general aspect it resembles an *Anodonta*, but the other examples show the characters of true *Unio*. This species is referable to the plain elongate type so common among living American Uniones, approaching in shape the *U. iris* of Lea as closely perhaps as any other species; for which reason the specific name *iridoides* has been chosen for the fossil form.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo.

UNIO LAPILLOIDES (sp. nov.).

Plate II, Figs. 5 and 6.

Shell rather small, transversely elongate, subelliptical in marginal outline; basal margin broadly convex or straightened along its median portion; front margin regularly rounded; dorsal margin gently convex; postero-dorsal margin broadly convex and sloping downward to the narrowly rounded posterior margin; valves having considerable convexity; beaks small, slightly prominent, situated at about one-third the length of the shell from the front. Surface plain, being marked only by the ordinary lines of growth.

Length, 36 millimeters; height, 17 millimeters.

This species, like the last, belongs to the elongate-oval type, and, although it is a somewhat larger shell than the living *U. lapillus* of Say, it approaches that species as closely perhaps as any other well known form. All the specimens yet found are in the condition of natural casts, which are more or less imperfect; but the features of the shell are sufficiently well shown to indicate a well marked species among the Jurassic Uniones.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo., where it is associated with the two preceding species in the bed of soft sandy shale which has already been mentioned. An example from a similar layer in the Atlantosaurus beds at Como, Wyo., although much distorted by pressure, seems also to belong to this species.

UNIO STEWARDI White.

Plate III, Figs. 1 and 2.

Unio Stewardi White, 1876. Report on the Geology of the Uinta Mountains, J. W. Powell, p. 110.

Unio Stewardi White, 1883. Review of the Non-Marine Fossil Mollusca of North America, C. A. White, in the Third Annual Report of the United States Geological Survey, p. 426, Pl. 3, Fig. 1.

Associated with the three foregoing species in a layer of soft sandy shale at the locality 8 miles north of Cañon City, Colo., some examples were found which seem to belong to the species which I published (op. cit.) under the name of *U. Stewardi.* This identification is doubtful, however, on account of the imperfection both of the specimens above referred to and of those upon which the species was originally proposed. The last named specimens, which were obtained from Jurassic strata near the banks of Green River in Southern Wyoming, being all fragmentary, served only to construct the restored outline, which is given on Plate III. The Colorado specimens evidently belong to the same type, if not to the same species, as *U. Stewardi.* They are also too unlike any other form now known to exist in our Jurassic rocks to make any other reference more satisfactory.

UNIO NUCALIS Meek & Hayden.

Plate III, Figs. 3, 4, 5, 6, and 7.

Unio nucalis M. & H., 1858. Proceedings of the Academy of Natural Sciences, Philadelphia, 1858, p. 52.

Unio nucalis M. & H., 1865. Palæontology of the Upper Missouri, p. 92, Pl. III, Fig. 13, a, b, c.

Unio nucalis White, 1883. Review of the Non-Marine Fossil Mollusca of North America, in the Third Annual Report of the United States Geological Survey, p. 426, Pl. 3, Figs. 2, 3, and 4.

The original specimens of this species were obtained by Dr. Hayden from the region of the Black Hills of Dakota, and they were the first specimens of that genus to be referred to the American Jurassic. Among the specimens sent by Professor Marsh from the Atlantosaurus beds at Como, Wyo., are some natural casts of a shell which belongs to the same type and probably to the same species. A considerable number of these casts have been found at Como, all of which are of smaller size than the average of the original specimens of *U. nucalis.* The specimens are all too imperfect for one to base a specific description upon them or to refer them with confidence to any known species. Fragments of the shell found with the casts show that the species is one of true *Unio.*

LIMNÆIDÆ.

Genus LIMNÆA Lamarck.

LIMNÆA ATIVUNCULA (sp. nov.).

Plate IV, Figs. 10 and 11.

Shell small, spire moderately slender; volutions about six in number, convex, the last one enlarged and somewhat longer than the spire. Surface marked by the usual lines of growth.

Length of the largest example in the collection, 8 millimeters; but their average length is considerably less.

The younger examples of this species are more slender than the adult specimens on account of the proportionally greater enlargement of the last volution upon reaching maturity. These younger examples are so slender as to suggest their reference to *Acella*, but the older shells have more the shape of true *Limnæa*.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo.

LIMNÆA CONSORTIS (sp. nov.).

Plate IV, Figs. 8 and 9.

Shell moderately small; spire short; volutions about five in number, convex, the last one inflated and much longer than the spire. Surface marked by the usual lines of growth.

Length of the largest example, 10 millimeters; breadth of the last volution, 5 millimeters.

This species, although small, is somewhat larger than the one last described, and it is also more robust than is usual with species of this genus, approaching *Physa* in that respect.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo.

LIMNÆA? ACCELERATA (sp. nov.).

Plate IV, Figs. 12, 13, 14, and 15.

Shell elongate ovoid; aperture a little shorter than the spire in adult shells; sides of the spire convex, rounding in more or less abruptly toward the apex, but when perfect the extreme apex is small and prominent; volutions convex, seven or eight in number when the shells have reached adult size, those near the apex being narrower and more transverse than the last two, during the production of which the axial extension of the shell was proportionally more rapid than in its earlier stages. Surface plain, being marked only by fine lines of growth.

Length, 20 millimeters; diameter of the last volution, 7 millimeters.

It is apparent at a glance that this shell is not a typical *Limnæa;* but after careful comparison with several other generic forms which have a

similar facies, I have not been able to refer it to any of them satisfactorily, and I therefore place it provisionally under *Limnæa*. Some of the specimens show a considerable deposit of callus upon the inner lip, in which case the flexure of the lower portion of the columella has something of the appearance of a fold such as some of the smooth forms usually referred to *Melanopsis* possess. That feature also suggests the relationship of this shell to *Stolidoma*, but there is no evidence that the axis of the spire has been absorbed, as is usually the case with the Auriculidæ. The character of the aperture also seems to render its reference to any of the Bulimidæ improper.

The collection contains a considerable number of small examples, which I at first regarded as belonging to another species; but after comparing them with the apical portion of the form here described I am quite convinced that they are the young of this species and represent the apical portion of the adult shell.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo., where it is associated with the two preceding and with the following species.

Genus PLANORBIS Muller.

PLANORBIS VETERNUS Meek and Hayden?.

Plate IV, Figs. 20 and 21.

Planorbis veternus M. & H. Proceedings of the Academy of Natural Sciences, Philadelphia, 1860, p. 418.

Planorbis veternus M. & H., 1865. Palæontology of the Upper Missouri, p. 107, Pl. IV, Figs. 1a, 1b, and 1c.

Planorbis veternus White, 1883. Non-Marine Fossil Mollusca of North America, in the Third Annual Report of the United States Geological Survey, p. 446, Pl. 3, Fig. 6.

A large number of small specimens of a small *Planorbis* were found associated with the specimens of *Limnæa* previously described in the Atlantosaurus beds 8 miles north of Cañon City, Colo., which are referred with some doubt to the *P. veternus* of Meek and Hayden, from the region of the Black Hills of Dakota. While it is not improbable that these Colorado specimens belong to a distinct species, it is not thought advisable at present to propose a new specific name for them. The principal difference between these and the Dakota specimens seems to lie in the less rapid increase of the diameter of the volutions of the Colorado specimens.

Genus VORTICIFEX Meek.

VORTICIFEX STEARNSII (sp. nov.).

Plate IV, Figs. 4, 5, 6, and 7.

Shell small; spire nearly flat, the apex being only slightly elevated; umbilicus moderately large, rapidly narrowing inward; volutions, after the first two at the apex, rapidly increasing in width at right angles to

the plane of the coil, strongly convex above, rounding abruptly into the umbilicus below, and bearing a prominent obtuse peripheral angle along the middle; suture deeply impressed; surface marked by numerous strong lines or small costæ of growth which have a convex backward curve upon the upper side of the volutions, and cross the space between the peripheral angle and the umbilicus with a concave backward curve.

Only a single example of this species has yet been found. It was sent by Professor Marsh from the Atlantosaurus beds at Como, Wyo. This specimen is very small, and has the appearance of having had a portion of the outer volution broken away, only three volutions remaining. The full adult size of the shell is therefore unknown. There seems to be no reason to doubt that this shell is strictly congeneric with the forms to which Meek gave the name *Vorticifex*. The only other known species of this genus occur in the Miocene Truckee Group of Northern Nevada and Southern Idaho.

The specific name is given in honor of Dr. R. E. C. Stearns, of the United States National Museum.

VALVATIDÆ.

Genus VALVATA Muller.

VALVATA SCABRIDA Meek and Hayden?

Plate IV, Figs. 1, 2, 3, and 19.

Valvata scabrida M. & H. Palæontology of the Upper Missouri, p. 113, Pl. IV, Figs. 2a, 2b.

Shell rather large; spire more or less depressed; volutions about five in number, convex, a transverse section of them at any point being almost a true circle; umbilicus rather small, deep. Surface marked by lines of growth which are conspicuous on well preserved examples.

Greatest diameter of an adult example, 13 millimeters; height, 11 millimeters; but in some cases the height is proportionally less.

The specimens which were described by Meek and Hayden (op. cit.) were not only imperfect, but they were small, and apparently represent only the apex of adult shells. This is certainly the case if the specimens here described belong to the same species, because they are very much larger. The apex of these large Colorado specimens compares so closely with the type specimens of Meek and Hayden that for the present I think it undesirable to propose a new specific name for them.

Locality and position.—Atlantosaurus beds, 8 miles north of Cañon City, Colo., where a large number of examples were found. The specimens described by Meek and Hayden were found near the Black Hills of Dakota.

VIVIPARUS GILLI Meek and Hayden.

Plate IV, Fig. 17.

See Palæontology of the Upper Missouri, Meek and Hayden, page 115, Pl. V, Figs. 3 a, 3 b, and Review of the Non-Marine Fossil Mollusca of North America, C. A. White, in the Third Annual Report of the United States Geological Survey, p. 470, Pl. 3, Fig. 8.

LIOPLACODES VETERNUS Meek and Hayden.

Plate IV, Fig. 18.

See Palæontology of the Upper Missouri, Meek and Hayden, page 116, and Review of the Non-Marine Fossil Mollusca of North America, C. A. White, in the Third Annual Report of the United States Geological Survey, p. 470, Pl. 3, Fig. 9.

NERITINA NEBRASCENSIS Meek and Hayden.

Plate IV, Fig. 16.

See Palæontology of the Upper Missouri, Meek and Hayden, page 109, and Review of the Non-Marine Fossil Mollusca of North America, C. A. White, in the Third Annual Report of the United States Geological Survey, p. 457, Pl. 3, Figs. 10 and 11.

Copies of Meek and Hayden's figures of these three species are given on Plate IV for the purpose of grouping together in this bulletin illustrations of all the fresh-water species which have been referred to the Jurassic of North America. These three forms, together with *Planorbis veternus*, *Valvata scabrida*, and *Unio nucalis*, were obtained by Dr. Hayden from the region of the Black Hills of Dakota, and the three whose names and places of publication are above given have not hitherto been found elsewhere. The *Neritina* is included here with the fresh-water forms, with which it seems to have been found associated.

CRUSTACEA.

OSTRACODA.

Multitudes of minute ostracods were found in the few layers of impure limestone of the Atlantosaurus beds near Cañon City, Colo., associated with the gasteropods which are described on the preceding pages. These, like the molluscan shells, are silicified; but by dissolving fragments of the limestone in hydrochloric acid the shells were liberated.

Desiring the opinion of the best authority concerning these ostracods, I sent a parcel of them to Prof. T. Rupert Jones for that purpose, and received the following reply, together with seven selections from the parcel of specimens which were sent to him:

"I have examined your specimens, and regarding them as internal casts my conclusions may be stated as follows:

"(1) *Metacypris Forbesii* Jones. Quart. Jour. Geol. Soc., XLI, p. 345,

Pl. VIII, Figs. 15 and 16. A short subglobose form, even rounder than Figs. 15 and 16.

"(2) *Metacypris Forbesii.* Ib., Fig. 11. This is even longer in proportion than our most oblong form.

"(3) *Metacypris* ———? This form is narrow, oblong, and compressed, and bears a distant resemblance to '*Cypris? conculcata*' Jones, Quart. Jour. Geol. Soc., XVI, p. 266, Pl. XVI, Figs. 3, a, b.

"(4) *Darwinula leguminella* E. Forbes. Quart. Jour. Geol. Soc., XLI, p. 346, Pl. VIII, Figs. 30 and 31.

"(5) *Cypris Purbeckensis?* Forbes sp. Quart. Jour. Geol. Soc., XLI, p. 347, Pl. IX, Fig. 3.

"(6) *Cypris* ———? Indeterminate; imperfect.

"(7) *Cypris* ———? Not determined; probably new."

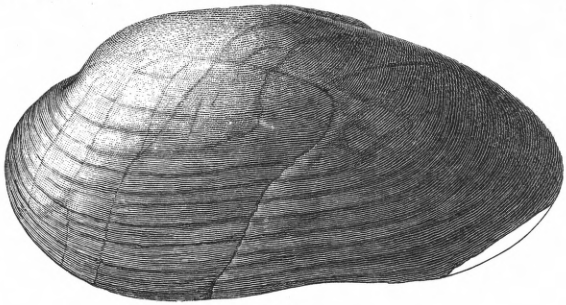
It is the intention of Professor Jones to make a further study of these forms; but it will be seen by his foregoing remarks that he regards these Rocky Mountain ostracods, so far as they have been determined, as being specifically identical with forms which he and others have published from the Purbeck formation in England. The "*Cypris? conculcata*," with which he compares the unnamed form No. 3, is from a fresh-water formation near Bahia, in Brazil, which I refer to the Neocomian in a work prepared for publication by the Brazilian Government.

Figures 22, 23, and 24 on Plate IV of this bulletin represent the form which Professor Jones refers to *Metacypris Forbesii;* and Figures 25 and 26 represent the variety No. 2 of his foregoing notes. I have not attempted to illustrate the forms referred to in his notes Nos. 3, 4, 5, 6, and 7.

PLATE I.

UNIO FELCHII.

Fig. 1. Right side view of an adult example.
Fig. 2. Dorsal view of the same.
Fig. 3. Left side view of another example.
Fig. 4. Left side view of still another example.
Fig. 5. Dorsal view of the same.
All natural size.



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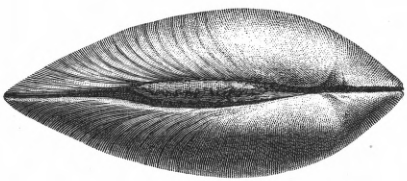

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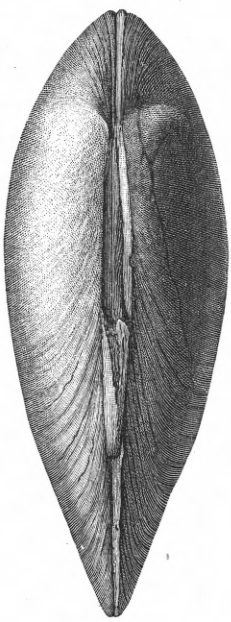

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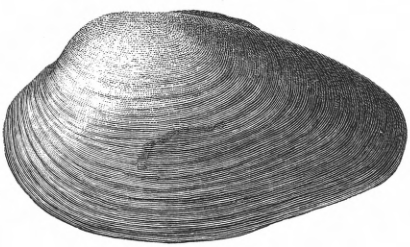

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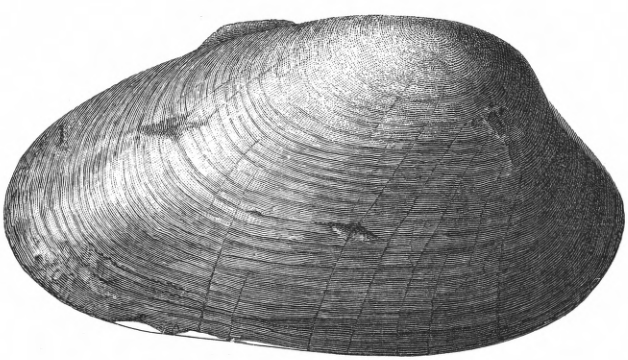


1

LAMELLIBRANCHIATA

PLATE II.

UNIO TOXONOTUS.

Fig. 1. Right side view of an old example.
Fig. 2. Dorsal view of the same.

UNIO IRIDOIDES.

Fig. 3. Right side view of the largest example found.
Fig. 4. Similar view of a natural cast of a smaller example.

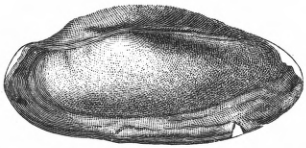
UNIO LAPILLOIDES.

Fig. 5. Left side view of a natural cast from near Cañon City, Colo.
Fig. 6. Upper view of a crushed example from Como, Wyo.

UNIO MACROPISTHUS.

Fig. 7. Left side view of a natural cast.

All natural size.



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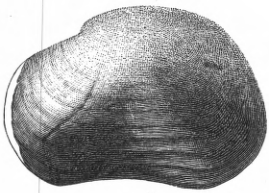

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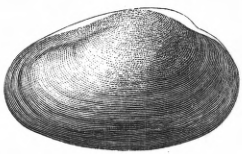

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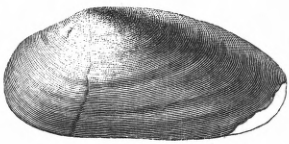

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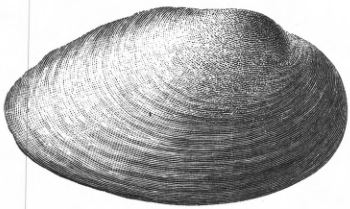

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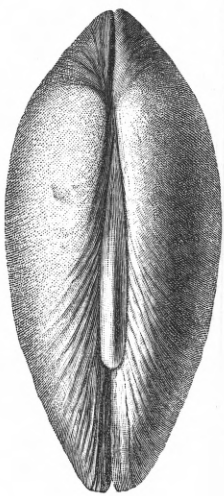

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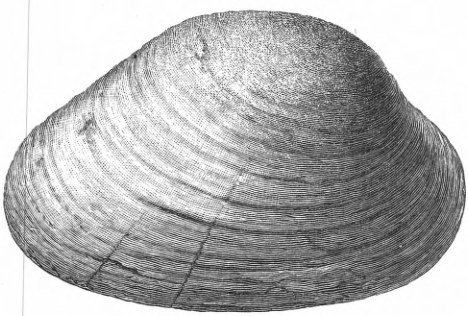

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LAMELLIBRANCHIATA.

PLATE III.

UNIO STEWARDI.

Fig. 1. Restored outline made from fragments of shells found in Southern Wyoming.

Fig. 2. Left side view of a natural cast from near Cañon City, Colo.; probably belonging to this species.

UNIO NUCALIS.

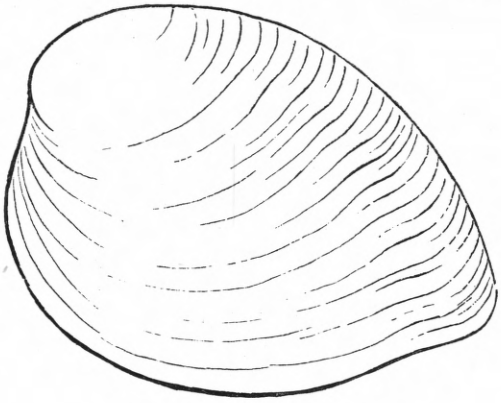
Fig. 3. Lateral view of a left valve partially restored from a specimen which is a little crushed.

Fig. 4. Dorsal view of the same, the right valve being restored in symmetry with the left.

Fig. 5. Dorsal view of one of Meek and Hayden's original types, somewhat restored, the specimen being a little crushed.

Figs. 6 and 7. Two imperfect natural casts from Como, Wyo., probably belonging to this species.

All natural size.



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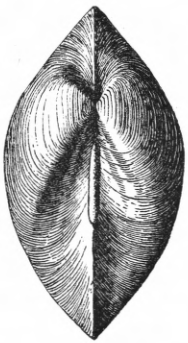

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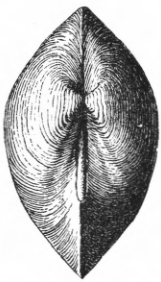

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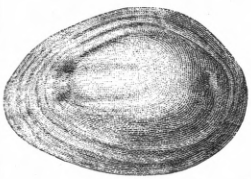

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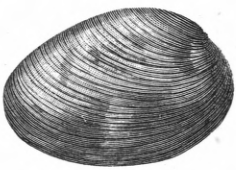

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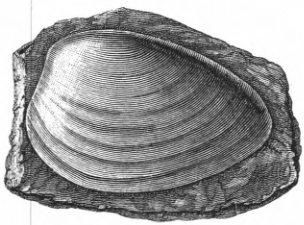

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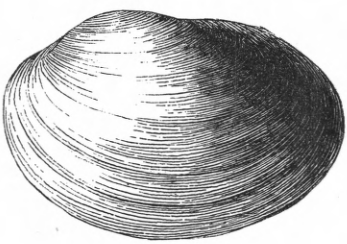

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LAMELLIBRANCHIATA.

PLATE IV.

VALVATA SCABRIDA.

Figs. 1, 2, and 3. Three different views of an example from near Cañon City, Colo., probably belonging to this species; somewhat enlarged; see also Fig. 19.

VORTICIFEX STEARNSII.

Figs. 4, 5, 6, and 7. Different views of the type specimens; much enlarged.

LIMNÆA CONSORTIS.

Fig. 8. Lateral view of a broken example; enlarged.
Fig. 9. A similar view of a smaller example; enlarged.

LIMNÆA ATIVUNCULA.

Fig. 10. Lateral view of one of the larger examples; enlarged.
Fig. 11. A similar view of a smaller example; enlarged.

LIMNÆA? ACCELERATA.

Figs. 12 and 13. Two views of an example nearly perfect; enlarged.
Fig. 14. The apical portion of a shell, showing the rapid increase in width of the two last volutions; enlarged.
Fig. 15. Apical portion of another example, showing the minute prominent apex, which is usually broken off; enlarged.

NERITINA NEBRASCENSIS.

Fig. 16. Copies of Meek and Hayden's original figures.

VIVIPARUS GILLI.

Fig. 17. Copies of Meek and Hayden's original figures.

LIOPLACODES VETERNUS.

Fig. 18. Copies of Meek and Hayden's original figures.

VALVATA SCABRIDA.

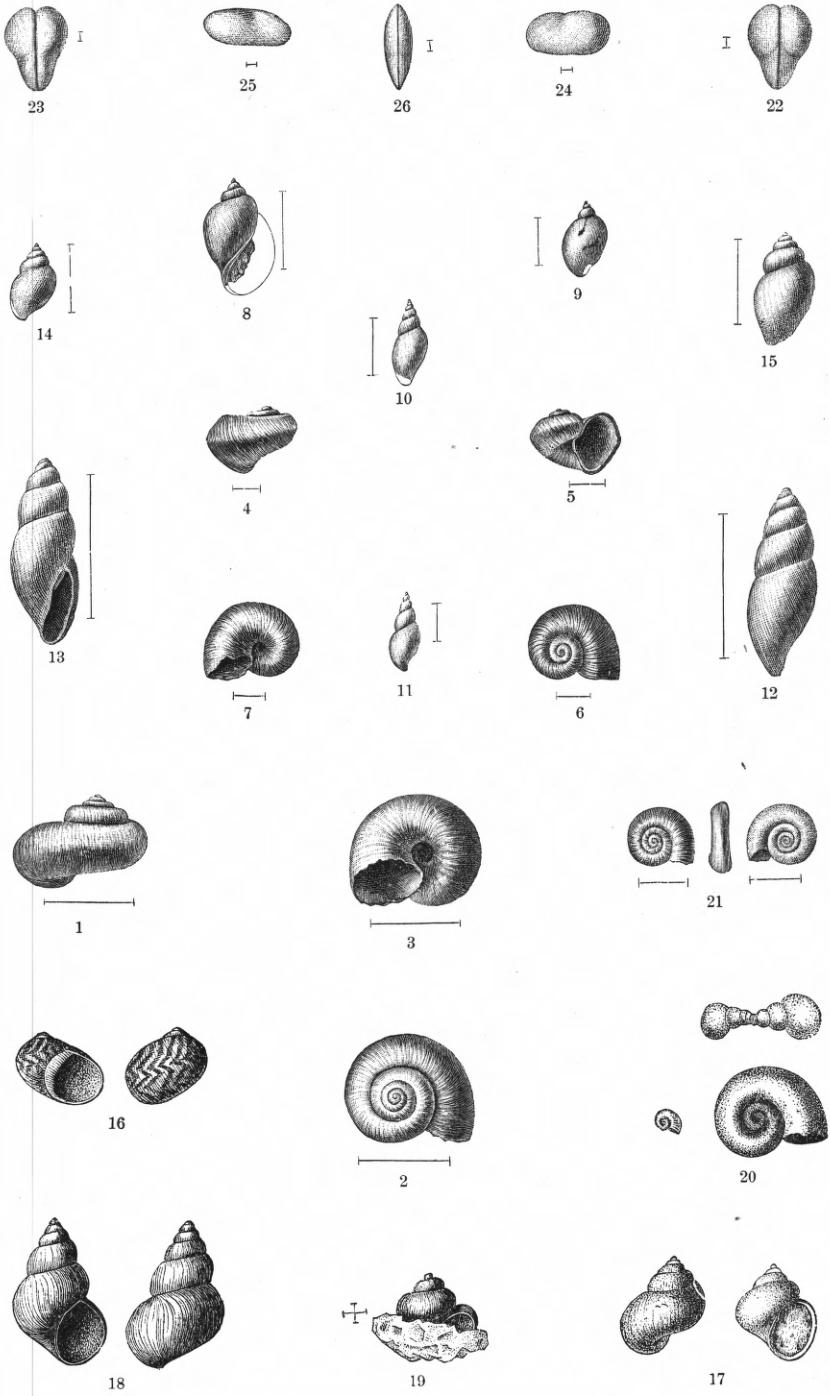
Fig. 19. Copies of Meek and Hayden's original figures; see also Figs. 1, 2, and 3.

PLANORBIS VETERNUS.

FIG. 20. Copies of Meek and Hayden's original figures.
FIG. 21. Different views of Colorado specimens, slightly enlarged.

METACYPRIS FORBESII.

Figs. 22, 23, and 24. Dorsal, ventral, and lateral views of an example of the more common form; much enlarged.
Figs. 25 and 26. Lateral and dorsal views of another associated form, probably only a variety; much enlarged.



OSTRACODA AND GASTEROPODA

INDEX.