APPENDIX.

ARTICLE XXXV.—*American Jurassic Mammals;* by Professor O. C. MARSH. (With Plates VII, VIII, IX, and X.)

IN previous numbers of this Journal, the writer has announced the discovery of Jurassic Mammals in this country, and has given brief descriptions of the more important forms brought to light.* Since the last article on this subject, a large amount of new material has been secured, including representatives of several hundred individuals. The remains consist not of lower jaws alone, but of various portions of the skull, and not a few vertebræ, limb bones, and other parts of the skeleton.

These fossils, although fragmentary, are usually well preserved, but owing to the peculiar conditions under which they were entombed, no two bones of the skeleton are as a rule found together. This fact, taken in connection with the very diminutive size of the animals themselves, and especially with the present brittle nature of the teeth and jaws, has rendered their investigation a work of great difficulty. The importance of the subject, however, and the fact that all the known remains of mammals from the Jurassic of this country are in the collection made by the writer, have led to a careful study of the whole material, and the results will be brought together in a Memoir now in preparation for the United States Geological Survey.

Some of the results of this investigation, and notices of several new forms recently discovered, are given below in the present article.

* This Journal, vol. xv, p. 459, 1878; vol. xviii, pp. 60, 215, and 396, 1879; vol. xx, p. 235, 1880; and vol. xxi, p. 511, 1881. See, also, Proceedings British Association, Montreal Meeting, p. 734, 1884.

In connection with this work, the writer has also examined the more important specimens from the Jurassic of Europe, and, likewise, the few specimens known from the Trias, in both Europe and this country.

The American Jurassic Mammals hitherto found are all from essentially the same geological horizon, in the Atlantosaurus beds, of the Upper Jurassic. The principal locality is in Wyoming, on the western slope of the Rocky Mountains, and remains of two or three hundred individuals have been obtained at this place alone. At other points in the same region, a few remains have been found. A second locality of importance is in Colorado, about three hundred miles south of the most northern known limit of these remains.

The other vertebrate fossils from this horizon are mainly dinosaurs, many of them of gigantic size, but some scarcely larger than the mammals. Crocodiles, turtles, small lizards, and fishes, are also well represented. A single bird (*Laopteryx*), and one small pterodactyl, have likewise been recognized from these deposits. More recently, various bones of small, anourous amphibians (*Eobatrachus agilis*) have been found, the first detected in any Mesozoic formation.* The deposits are lacustrine, as shown by the fresh-water shells they contain.

In investigating these American Jurassic Mammals, it was necessary to compare them, first of all, with those from the same formation in Europe. On this subject, the elaborate memoir of Owen, on British Mesozoic Mammals, was taken as the main authority.†

The first specimens discovered in this country proved to be very near allies of European forms, and most of those since found show a remarkable resemblance to others described by Owen. Some fragmentary specimens cannot indeed be distinguished from the English fossils, but where the remains are more complete, various differences are seen, which appear to be distinctive. A few, well-marked, American genera have no known representatives in Europe, while some forms found there are unknown here.

One difficulty in the investigation of the remains from the two widely-separated regions arises from the necessity of relying mainly upon figures for comparison. Again, these minute, delicate fossils are often embedded in a matrix from which they cannot be removed without great danger of injury or destruction. Hence, the jaws and teeth in many cases must be examined and described from the single side exposed. If

* Proceedings British Association, Aberdeen Meeting, p. 1033, 1885.

† Monograph of the Fossil Mammalia of the Mesozoic Formations. Palæontographical Society, vol. xxiv, London, 1871.

the opposite side of a similar jaw should be shown in another specimen, the two may easily be regarded as distinct. This may also be the case where upper and lower jaws are found separately. Hence, a large amount of material becomes necessary for even a proximate correlation of the closely related forms.

Plagiaulacidæ.

One of the first American specimens discovered resembled strongly the minute lower jaws first described by Falconer, under the name *Plagiaulax*, and since investigated by Owen, Flower, and others, whose discussion of the habits and affinities of these peculiar mammals forms a well-known chapter in the history of palæontology. Of this genus, only the lower jaws were known, and this is one reason for the wide divergence of opinion as to the nature of the animals they represent. The lower jaws found in America were regarded by the writer as indicating a distinct genus, *Ctenacodon*, two species of which he has since described.

Among the separate upper jaws found in the Jurassic of England were two or three described by Owen, under the generic name *Bolodon*, but with no suspicion that they were in any way related to *Plagiaulax*. From American deposits, also, somewhat similar jaws were obtained more recently, and as they were apparently quite distinct from *Bolodon*, they were described by the writer as representing a new genus, *Allodon*. The molar teeth in one specimen resembled those of *Plagiaulax*, and the writer in his description expressed the opinion that *Allodon* should probably be placed in the *Plagiaulacidæ*. A natural inference was that *Bolodon* was the upper jaw of *Plagiaulax*, and *Allodon*, of *Ctenacodon*. However this may be in regard to the European forms, the specimens now known make it clear that the American genera are quite distinct.

The molar teeth of *Allodon* and *Ctenacodon* are of the same general type, and it is still difficult, if not impossible, to distinguish them when detached from the jaws. The premolars, however, and especially the incisors, differ in the two genera, and when well preserved may often be separated with certainty.

Allodon.

In *Allodon*, the superior dentition on each side appears to be as follows:

Incisors 3; canine 0; premolars 5; molars 2.

The lower dentition is uncertain, but is probably the following:

Incisors 1; canine 0; premolars 4; molars 2.

The upper molar series in the type specimen of *Allodon* is well shown in Plate VII, figures 1 and 2. The five premolars have tuberculate crowns, and all appear to be inserted by two fangs. The first and second have each one external, and two internal cones. The third premolar has a small additional cusp. These three premolars diminish in size from before backward. The next premolar, or fourth, is much larger, and has its crown flattened on the inner side. There are three tubercles on the outer border, and four, on the inner margin. The fifth in the series is still larger, and has a more rounded crown. There are three lobes on the outer side, and the same number on the interior face.

The two true molars have low crowns, which are divided into an outer and inner half, by a deep-worn groove. Each half bears three low tubercles, of nearly equal size. The last molar has its longitudinal groove on a line with the inner margin of the other teeth.

The superior incisors of this genus now known are represented in the detached premaxillary of *Allodon fortis*, Plate VII, figures 7–10. The first incisor was very small. The second was the main front tooth, much larger than the third. In the type specimen of *Allodon*, represented in Plate VII, figures 1 and 2, no suture is visible behind the first small tooth (*a*), hence, this may possibly be a weak canine instead of the third incisor. In *Allodon fortis*, figure 7, and also in the type of *Bolodon*, Owen, the suture between the premaxillary and maxillary is distinct.

The large second incisor of *Allodon* is a peculiar tooth, and was evidently exposed to the full wearing action of a strong lower incisor, somewhat similar to that of a rodent. This lower tooth has not been found in place, but the one represented in Plate VII, figures 14 and 15, may, with considerable probability, be referred to this position. The remaining lower teeth have not been found associated with the upper jaws, but they evidently resembled those of *Ctenacodon*, in some of their most important characters.

In comparing *Allodon* with *Bolodon*, we evidently have two nearly related forms. So far as at present known, *Allodon* has three incisors instead of two, a larger number of teeth in the premolar and molar series, and likewise shows other differences of less importance.

The affinities of these peculiar fossils, and the inferences in regard to their habits and food, which may be drawn from the specimens now known, will be fully discussed by the writer elsewhere.

Allodon fortis, sp. nov.

The present species appears to be generically identical with the type specimen of *Allodon laticeps*, but is represented by remains of much larger size. The premaxillary shown on Plate VII, figures 7–10, may be taken as the type specimen. A number of upper molar teeth, and the large lower incisor (figures 14 and 15, of the same Plate), are also referred to this species.

The first incisor in this premaxillary was very small, and situated close to the median line. It is wanting in the present specimen, but its size and position are indicated in the above figures. The second incisor is large and prominent, and is the principal front tooth. It has a distinct crown, which is covered with enamel, and consists of one large main cusp, with a small posterior cone. The lower surface is much worn, evidently by an opposing lower tooth which bore directly against it, from its apex to the small posterior prominence. The sides of the crowns show no signs of wear. The third and last incisor is much smaller, and is separated from the second by a short diastema. It has a distinct crown covered with enamel, but shows no marks of attrition. It is situated a little in advance of the suture with the maxillary, shown in figure 7, *s*, Plate VII.

A second specimen referred to this species is shown in figures 11–13, Plate VII. It is a portion of a left upper jaw containing three premolars, apparently the first, second, and third. The first two of these have a single external cone, and two inner cones, and the second tooth is larger than the first. The third premolar is still larger, unlike the corresponding tooth in *Allodon laticeps*, and has a second exterior cone behind the main one. Above this tooth, there is a large cavity, apparently the entrance of the antorbital foramen. This is shown in figure 11, *f*, Plate VII.

The large lower incisor which met the prominent one above is probably represented in figures 14 and 15. This tooth is faced with enamel in front, and grew from a persistent pulp, like the incisor of a rodent. The summit is incomplete, and hence, the shape of the worn surface cannot be determined.

The specimens here described indicate that *Allodon fortis* was the largest mammal of this group hitherto discovered in the Jurassic. In bulk, it was three or four times as large as *Allodon laticeps*, and about the size of a rat.

The only known remains of this species are from the Atlantosaurus beds of the Upper Jurassic, in Wyoming.

Ctenacodon.

The genus *Ctenacodon* was based upon lower jaws, one of which is represented in Plate VIII, figure 1, and others, in figures 4, 7, and 8. The single, long, pointed incisor, the four, compressed, cutting premolars, and the two, minute, tubercular molars, form together a peculiar dentition. The long, sharp incisor shows no signs of wear whatever, and hence could not be opposed to the large upper incisor of *Allodon*. Its position was close to its fellow, and the two evidently acted together, as indicated in figure 9, Plate VIII. The four premolars form a close-set series, with their upper margins on a curve, all more or less notched. Some specimens, at least, show distinct marks of wear on the outer sides of the crowns, which are sometimes worn to a uniform surface. The two small tuberculate molars are of the *Microlestes* type, with a deep longitudinal groove on the upper surface of the crowns.

The entire upper dentition of *Ctenacodon* is not known with certainty, but it probably corresponded in its main features to that of *Allodon*. A portion of the upper jaw, with typical premolars, is shown in Plate VIII, figures 2 and 3. The posterior premolars, especially the last two, show strong marks of attrition on the inner sides of the crowns, and these were opposed to the compressed premolars below, forming together a most effective apparatus for cutting.

Some of the lower jaws at present referred to *Ctenacodon* apparently show no signs of wear on the premolars, and as the large incisor is not preserved, it is impossible to say definitely that they may not pertain to *Allodon*. It is likewise quite probable that some of the lower jaws considered as *Plagiaulax* may belong with some of the specimens now known as *Bolodon*. The exact correlation of the two forms cannot be determined with certainty until the upper and lower jaws are found together in position.

Ctenacodon may be distinguished from the type of *Plagiaulax* (*P. Becklesii*) in having four premolars instead of three. The summits of these teeth alone are notched, and the sides smooth, not obliquely grooved as in *Plagiaulax*. The condyle, moreover, is separated from the angle of the jaw, not confluent with it. *Ctenacodon*, also, has the angle of the jaw not only strongly inflected, but its outer margin efflected into a wide horizontal shelf, making this one of the most peculiar features of the genus.

The vertical posterior condyle in *Ctenacodon* implies a strong post-glenoid process, that would confine the jaw to a vertical motion.

In *Ctenacodon*, the mental foramen is large, and situated below the middle of the diastema. The dental foramen is under the last molar, but its entrance is partially concealed by a ridge descending from the base of the tooth to the inflected border of the angle.

In none of the specimens of *Ctenacodon* preserved is there any trace of a mylohyoid groove.

Ctenacodon potens, sp. nov.

A third species of *Ctenacodon*, much larger than *C. serratus*, is represented by several jaws and isolated teeth, discovered since the first species was described. The most important of these specimens, which may be taken as the type, is the right upper jaw represented in Plate VIII, figures 2 and 3. The lower jaw with incisor, figured on the same Plate, may also be referred to this species. A second lower jaw in better preservation, but without the incisor, may likewise be included, although somewhat larger in size.

The upper jaw above mentioned agrees in its general shape with that of *Allodon*. It indicates a short, broad skull, with strong, expanded, zygomatic arches. There is a small antorbital foramen, as in *Allodon*. The four premolars present increase in size from before backward. The first and second are of the *Allodon* type. The last two have strong marks of attrition on the inner surface of their crowns, as shown in figure 2, of the same Plate. They differ from the corresponding teeth in *Allodon*, in being more compressed, and adapted to cutting.* There were apparently two true molars, which are wanting in the present specimen, but their position and size are similar to those of the same teeth in *Allodon*.

The left lower jaw represented in figures 7, 8, and 9 shows that the incisor in this species was very large in size, and a most effective weapon. It grew from a persistent pulp, and its massive base extended back under the fourth premolar. The crown is oval in outline at the margin of the jaw, somewhat more compressed above, and sharply pointed at the apex. There is a shallow groove on the outer surface of the lower half of the crown, and a corresponding depression along the middle of its inner face. A careful examination shows no signs of wear on any part of the crown.

The premolars are separated from the incisor by a long diastema. The first premolar is small, without serrations, and is placed close to the second. The latter is larger, inserted by two fangs, and has the summit faintly notched. The third premolar was still larger, but is so much fractured in the

* A somewhat similar tooth of *Microlestes* is figured by Owen in Mesozoic Mammals, Plate I, fig. 16.

present specimen that its form and dimensions are uncertain. The fourth premolar is very large, notched at the summit, and with its outer face showing distinct marks of wear.

The first true molar is small, and its crown much inclined backward. The second true molar is wanting, but its alveoli show that it was also small, and placed below the first molar.

In this species, the series of four lower premolars is placed on a curve, and acts as a single cutting blade against the compressed upper premolars. This curve is completed behind by the two molars, which have their crowns inclined outward.

The second and larger lower jaw referred to this species gives some additional characters. The third and fourth premolars show distinct traces of wear on their outer surfaces. The first true molar is placed obliquely, as in the previous specimen, and has been subjected to much attrition. The last true molar was situated lower than the first, and was also oblique. In *Ctenacodon serratus*, the two lower molars are nearly on a level. The present specimen shows that the angle of the jaw was strongly inflected, and there was likewise a ridge on the opposite outer margin. The coronoid process had its front border more nearly perpendicular than in *Ctenacodon serratus*. There is no trace of a mylohyoid groove.

The known specimens of this species are from the Upper Jurassic deposits of Wyoming.

Dryolestidæ.

The first American mammal found in the Jurassic, and a large proportion of those since discovered, belong to a peculiar family which the writer has called the *Dryolestidæ*. It includes several genera and numerous species from this country, and is likewise represented among the forms found in Europe.

The type species of the group, *Dryolestes priscus*, was based upon a characteristic lower jaw, although the specimen was imperfect. A nearly complete lower jaw of the species is represented on Plate IX, figure 2. An allied species, *Dryolestes vorax*, is shown on the same Plate, by figures 3 and 4. *Stylacodon*, *Asthenodon*, and *Laodon*, other genera of this family, are likewise represented on the same Plate.

The upper jaws of several genera of this family are now known with tolerable certainty, and these will be figured and described fully in the Memoir now in preparation.

All the genera of this family have more than the typical number of teeth (44), and the general characters of the inferior dentition are well shown in Plate IX. The lower teeth form a close-set series, without diastemas, or marked interspaces.

There are three, or four, incisors, and in those preserved, each has a distinct crown, and the series diminishes in size from in

front backward. The canine is inserted by two fangs, more or less distinct, and in most forms, its crown is prominent and trenchant. Three or four premolars follow, increasing in size backward, with the last usually very prominent, and in some forms, larger than the canine. These premolars all have two roots, and a compressed crown. All have one main cusp, and a small posterior heel. There is usually a small anterior cusp, especially on the posterior teeth.

The molar teeth are from six to eight in number, and are essentially identical in form, and usually distinct from the premolars. The crown consists of one main external cone, high and pointed, and three internal cusps, which vary much in development in the different genera. Seen from the outside, these teeth appear to be inserted by a single fang, but, in most cases, each has two roots, although these are nearly or quite connate. When the jaw is embedded in the matrix, and the diminutive teeth uncovered as far as safety will permit, the features of one side only of the molars can be determined. Thus in figure 1, Plate IX, the outer exposed side of one lower jaw (*Stylacodon*) is shown, while in figure 2, the inner side of another jaw (*Dryolestes*) is represented. In figures 3 and 4, the two sides of the same jaw are placed together, and the main characters of the lower molar teeth of *Dryolestes* are thus made evident.

There are seven superior molars, and these have one main inner cone, and three outside cusps that vary in size and proportions in the different genera.

Dryolestes and Stylacodon.

The two genera most nearly allied in dentition are *Dryolestes* and *Stylacodon*, typical examples of which are shown on Plate IX. The number of lower teeth in the best preserved specimens appears to be the same in each, while the incisors, canine, and four premolars, show no marked differences. In *Dryolestes*, the eight molars which follow are all of one type, and differ but little except in size. All have the inner middle cone of the crown as high as, or higher than the outer main cone. In *Stylacodon*, the first two of these teeth resemble the anterior premolars in shape, and like them show from the outside double fangs. The main external cone is quite as high as the opposite cusp.

In *Dryolestes*, moreover, the lower jaw is comparatively short and massive, deep below the molar teeth, with its lower margin strongly convex. The condyle in the best preserved specimen is concave transversely, and has its lower margin nearly on a line with the summits of the molar teeth.

In *Stylacodon*, the lower jaw is long and slender, and constricted in front of the coronoid process, which slopes well upward and backward. The condyle is convex transversely, and placed considerably above the line of the teeth. The jaw is shallow below the molars, scarcely exceeding the height of the teeth themselves, while the lower border in this region is nearly straight. These differences may be readily seen in the two specimens shown on Plate IX, figures 1 and 2. The mylohyoid groove is well developed in both genera, and its position is essentially the same in each.

In *Dryolestes*, the mental foramen is below the first premolar. The dental foramen is beneath the front margin of the coronoid process, and at this aperture, the mylohyoid groove begins.

Asthenodon.

The genus *Asthenodon*, the type species of which is described below, agrees with the above genera in the more important characters of the lower dentition, but differs, in having the entire series of teeth much more uniform in size, and but eleven teeth behind the canine. The type of this species is the lower jaw shown in Plate IX, figure 7. A second specimen referred to this species is the anterior part of another jaw, shown in figure 6. The former jaw shows a weak canine (*a*), followed by three premolars, each with two fangs. Behind these, in place of the large, trenchant premolar seen in *Dryolestes* and *Stylacodon*, is a small tooth, which from its shape may be regarded as the first molar. The remaining teeth agree in their more important characters with the corresponding molars of *Dryolestes*. The second specimen, figure 6, shows a similar weak canine, and, in front of it, the four incisors in place, increasing rapidly in size forward, the front one being larger than the canine.

Asthenodon segnis, gen. et sp. nov.

In the genus *Asthenodon*, the inferior dentition on each side is as follows:

Incisors 4; canine 1; premolars 3; molars 8.

The largest tooth in the entire lower series is the first incisor, Plate IX, figure 6, 1. The remaining incisors decrease in size backward, as shown in the same figure, 2, 3, and 4. The canine (*a*) is small and weak, and its crown resembles that of the incisors. It is implanted by two roots, which are nearly connate. The three premolars behind the canine have each two fangs, and increase in size from first to last, as shown in figure 7, of the same Plate. The following seven teeth, judging from

the shape, are molars, and behind them is the alveole of one more. These molars agree in general form with those of *Dryolestes*. The form of the lower jaw also is similar in the two genera. The upper jaw of this genus is not known.

The specimens representing this species indicate an animal about the size of a weasel. They are from the Atlantosaurus beds of Wyoming Territory.

Laodon.

A fourth genus, *Laodon*, while agreeing in the general type of lower molar teeth with the above forms, differs widely from them in other respects. The molars in this genus have the outer main cone high and pointed, as in the above genera, but the inner opposite cusp is greatly reduced in size, as shown in the type specimen represented in Plate IX, figure 5. There appear to have been eight molar teeth, six of which are well preserved. In front of these, are two premolars of nearly equal size, and between these and the canine, there were apparently three more, each with two fangs, making thirteen teeth in the premolar and molar series. The canine had two roots, and the last incisor was placed closely in front of it.

In this specimen, the dental foramen is situated below the summit of the coronoid process. Its aperture is placed obliquely, opening backward and upward, and from its outer margin, the deep mylohyoid groove extends forward and downward, rapidly descending below the lower border of the ramus.

This lower jaw is intermediate in form between *Dryolestes* and *Stylacodon*. It has the slender straight ramus of *Stylacodon*, with even a stronger constriction behind the molar teeth, but the jaw is deeper below the molar series, and the lower margin is convex, as in *Dryolestes*. The molar teeth resemble those of *Peraspalax*, Owen, but in that genus there is a less number of teeth, and other features not seen in the present specimen.

The upper jaw of this genus has not yet been identified.

Laodon venustus, gen. et sp. nov.

In the type specimen of this species, the inner side only of the lower jaw is shown. The alveolar border is nearly straight, while the lower margin is strongly convex. The anterior portion of the ramus is very shallow, but little, if any, deeper than the crowns of the teeth it contained. There is a well-marked mylohyoid groove, which begins at the dental foramen, and extends forward and downward, until it is lost below, directly under the second molar. The angle of the jaw extends well backward, and was not inflected, although somewhat thickened

along the lower margin. The pterygoid fossa is deep and wide. The coronoid process was large, but its exact form cannot be determined.

The type specimen of the present species is from the Upper Jurassic deposits of Wyoming.

Diplocynodontidæ.

A third group of Jurassic Mammals is known at present from three genera, which have been found only in this country. The most typical form, *Diplocynodon*, is represented on Plate X, figure 3, by the specimen first described. This fossil indicates one of the largest mammals yet found in the Jurassic. In this genus, there were at least three lower incisors, directed well forward. The canine is very large, elevated, and trenchant, and inserted by two strong fangs. Behind this, there are twelve teeth, all essentially of the same type, so that, from the outer side alone, it is difficult, if not impossible, to distinguish the premolars from the molars. The crowns of these teeth are composed of a main external cone, with a small, elevated lobe in front, and a lower one behind. This is repeated on a reduced scale on the inner side, except that the posterior cusp is rudimentary, or wanting. The antero-posterior faces of the crowns are deeply excavated, and grooved.

The jaw is elongate, and gently curved below. The coronoid process is large, and elevated. The condyle is placed very low, nearly on a line with the teeth. The angle of the jaw is produced into a distinct process (*d*), the lower margin of which bends outwards, although the process as a whole has a slight inward direction.

In *Diplocynodon victor*, the mental foramen is beneath the interspace between the second and third premolars. The dental foramen is large, and is situated intermediate between the last molar and the angle of the jaw. From its front margin, the narrow straight mylohyoid groove extends forward, nearly parallel with the lower margin of the ramus.

An upper jaw referred to this species contains the canine and eight succeeding teeth in excellent preservation. The canine is very large, and has two distinct fangs. The molar teeth have one, main, external cone, and two lateral cusps, which rise from a strong basal ridge. On the inner side, there is one main cone, with a small posterior heel. The outer face and the sides of the upper molars are deeply sculptured with irregular grooves.

The European genus *Amphitherium* may possibly belong to this family, but the lower canine has only a single root, and the molars appear quite different from those of the American forms.

Docodon.

Another genus (*Docodon*) of this family may be distinguished from *Diplocynodon* by having, in the lower jaw behind the canine, eleven teeth instead of twelve. The canine has two fangs, as in the latter genus, and the molar teeth correspond closely in form. The symphysis is very long, and the mylohyoid groove extends forward to its upper border. The type specimen of this genus is shown in Plate X, figure 2.

In *Docodon*, the dental foramen is further back than in *Diplocynodon*, and the mylohyoid groove, leading out of it, is deep and straight as far as the last premolar.

Enneodon.

A third genus, *Enneodon*, described below, is represented by two specimens, one of which is shown on Plate X, figure 4. The lower jaw is comparatively short and robust, and contained only nine post-canine teeth, all of the same type.

Enneodon crassus, gen. et sp. nov.

The canine in *Enneodon* is large, and, as in the other genera of this family, is inserted by two well-separated fangs. Seen from the outside, its crown resembles that of a true molar, but the anterior lobe is wanting. The second premolar is larger than the first, not smaller, as in the type of *Diplocynodon*. The premolars, although of the same general form as the molars, have the surface of the crown more grooved, or striate.

Enneodon affinis, sp. nov.

A second specimen of this genus agrees with that last described in the main features of its dentition, but the lower jaw is less robust. The canine is also more slender, and there is a small diastema behind it. The first three premolars increase in size backward, but are all of similar form. The angle of the jaw is considerably below the lower margin of the ramus.

The principal dimensions of this specimen are as follows:

Space occupied by nine premolar and molar teeth	16·mm
Depth of jaw below first premolar	2·
Depth of jaw below first molar	3·25
Height of first premolar above jaw	1·5
Height of second molar above jaw	2·
Antero-posterior diameter of second molar	2·

The fossils on which the two species of *Enneodon* are based were found in the Atlantosaurus beds of the Upper Jurassic, in Wyoming.

Spalacotheridæ.

The type genus of this family is *Spalacotherium* of Owen, but it is probable that he included more than one generic form under this name, in the various specimens described. In this country, one well-preserved jaw has been found, which appears to indicate a distinct genus (*Menacodon*), and is described below. This specimen is represented on Plate X, figures 5 and 6.

In the typical specimens of *Spalacotherium*, the premolar and molar teeth are ten in number, and of the same general form. The crown consists of one, main, external cone, high and pointed, and two, short, inner cusps, nearly equal in size, in front of and behind the main cone. The canine has two fangs, and there is little or no diastema behind it.

In *Menacodon*, the molars have the same general form, but there appear to be but seven in the post-canine series. The crowns also are shorter and more robust. The canine is small, and has two roots.

Menacodon rarus, gen. et sp. nov.

In this species, the lower jaw is comparatively slender, and its inferior border is strongly convex, longitudinally. The canine was small, and directed well forward. The first three premolars are separated slightly from the canine, and from each other. The three following teeth, which may be regarded as true molars, are larger and more elevated, and behind these was the last molar, somewhat smaller in size.

In the type specimen of *Menacodon*, there is no sharply defined mylohyoid groove, but a shallow depression takes its place, as indicated in Plate X, figure 6.

In *Spalacotherium*, there is a well-defined mylohyoid groove.

The unique specimen on which the present species is established was found in the Upper Jurassic of Wyoming.

Tinodontidæ.

This family is well represented by American forms, one of which, the type species of *Tinodon*, is shown on Plate X, figure 1. *Phascolotherium*, Owen, appears from its dentition to be an allied form, but differs in several important points, and may yet be found to represent a distinct family. The premolar and molar teeth have nearly the same form in both genera, but in *Tinodon*, there is a larger number of post-canine teeth. The coronoid process, also, is vertical, and the angle of the jaw is not inflected. The premolars have the same general shape as the molars, the crowns being composed essentially of three

pointed cusps, one, main, outer cone, and two, smaller cusps, one in front and one behind, on the inner side. There is a strong cingulum on the inner surface, which may develop into an anterior lobe, or posterior heel. The mylohyoid groove is distinct. The condyle in *Tinodon* is rounded, and somewhat transverse, and is separated from the jaw by a distinct neck.

In *Tinodon bellus*, the dental foramen is large (Plate X, figure 1, *f*), and looks downward and backward. It is placed somewhat behind the anterior margin of the coronoid process, and somewhat above the middle line of the ramus. The deep mylohyoid groove (*g*) leads from this opening, forward and downward.

Triconodontidæ.

Another family related to the one last described is represented by the genus *Triconodon* of Owen, and by one or two American forms. In this group, the premolars are unlike the molars. The latter are large, and their crowns are composed of three, nearly equal, trenchant cusps. The premolars are compressed and trenchant, but lack the anterior cusp. There is apparently more than one genus included under the specimens referred by Owen to *Triconodon*, but more specimens will be required to separate them.

Priacodon, gen. nov.

One of the American forms, which appears to be generically distinct from the type of *Triconodon*, is represented below, on Plate X, figure 9, under the name *Priacondon ferox*. The type specimen, on which it is based, was originally placed by the writer in the genus *Tinodon*, and the species named *Tinodon ferox*. This specimen is a right lower jaw, with most of the teeth in position. There are three premolars, and four molars. The premolars have one main cone, pointed and compressed, with a low cusp in front, and a larger one behind. The last premolar is large. The penultimate molar has four distinct cones instead of three. The canine was large, and directed well forward. The coronoid process is high, and inclined backward. The mylohyoid groove is nearly parallel with the lower margin of the jaw, and extends forward to the symphysis. The latter is strongly marked.

Paurodontidæ.

A peculiar genus, *Paurodon*, widely different from any form hitherto found in this country or Europe, is represented at present by a single specimen, a left lower jaw. This is shown

on Plate X, figures 7 and 8. The entire premolar and molar series consists of only six teeth, the main features of which are seen in the figures cited. The canine is large, nearly erect, and is apparently inserted by a single fang. There is a distinct diastema between this and the first premolar. The latter is small. The lower jaw is short and massive, and there is a deep mylohyoid groove (*g*).

The molar teeth of *Paurodon* appear to agree in the general features of their crowns with those of *Achyrodon* and *Peralestes*, but the figures given by Owen of the specimens described under these names show them to be quite distinct from the present genus.

Paurodon valens, gen. et sp. nov.

In this genus, there were apparently two lower premolars, and four molars, all separated somewhat from each other. The premolars have a single main cusp, and a low posterior heel. Each is implanted by two roots. The molars have a single main external cone, and two low inner cusps. The mylohyoid groove extends from the pterygoid fossa to the symphyseal surface, which is large. The mental foramen is below the diastema between the canine and the first premolar.

The upper jaw of this peculiar fossil is not known.

The type specimen of this unique form is from the Upper Jurassic deposits of Wyoming Territory.

The main object of the present article is to present a typical series of the remains of known American Jurassic mammals. A discussion of the closer relations of these to the mammals from the same formation in Europe, as well as to both older and more recent forms, will be reserved for the Memoir now in course of preparation.

The vertebræ, limb bones, and other parts of the skeleton of mammals, found with the jaws and teeth here described, cannot yet be definitely associated with the latter, but an attempt to do this will be made in the Memoir.

The genera and species of American Jurassic mammals now known are given in the list below. All have been described by the writer, in this Journal. One figure, at least, of a typical form of each new genus proposed, has also been given, either in the original description, or in the present article.

The list is as follows:

Plagiaulacidæ.

Allodon laticeps.	Amer. Jour. Sci.,	vol.	xxi,	p. 511, 1881.
" fortis.	"	"	"	xxxiii, p. 331, 1887.
Ctenacodon serratus.	"	"	"	xviii, p. 396, 1879.
" nanus.	"	"	"	xxi, p. 512, 1881.
" potens.	"	"	"	xxxiii, p. 333, 1887.

Dryolestidæ.

Dryolestes priscus.	Amer. Jour. Sci.,	vol.	xv,	p. 459, 1878.
" vorax.	"	"	"	xviii, p. 215, 1879.
" arcuatus.	"	"	"	xviii, p. 397, 1879.
" obtusus.	"	"	"	xx, p. 237, 1880.
" gracilis.	"	"	"	xxi, p. 513, 1881.
Stylacodon gracilis.	"	"	"	xviii, p. 60, 1879.
" validus.	"	"	"	xx, p. 236, 1880.
Asthenodon segnis.	"	"	"	xxxiii, p. 336, 1887.
Laodon venustus.	"	"	"	xxxiii, p. 337, 1887.

Diplocynodontidæ.

Diplocynodon victor.	Amer. Jour. Sci.,	vol.	xx,	p. 235, 1880.
Docodon striatus.	"	"	"	xxi, p. 512, 1881.
Enneodon crassus.	"	"	"	xxxiii, p. 339, 1887.
" affinis.	"	"	"	xxxiii, p. 339, 1887.

Spalacotheridæ.

Menacodon rarus. Amer. Jour. Sci., vol. xxxiii, p. 340, 1887.

Tinodontidæ.

Tinodon bellus.	Amer. Jour. Sci.,	vol.	xviii,	p. 216, 1879.
" robustus.	"	"	"	xviii, p. 397, 1879.
" lepidus.	"	"	"	xviii, p. 398, 1879.

Triconodontidæ.

Triconodon bisulcus.	Amer. Jour. Sci.,	vol.	xx,	p. 237, 1880.
Priacodon ferox.	"	"	"	xxxiii, p. 341, 1887.
(*Tinodon ferox*).	"	"	"	xx, p. 236, 1880.

Paurodontidæ.

Paurodon valens. Amer. Jour. Sci., vol. xxxiii, p. 342, 1887.

None of the known Mesozoic mammals appear to have been truly herbivorous. *Stereognathus*, which has been considered as such, from its molar teeth, cannot fairly be regarded as evidence, since it was based, not upon part of a lower jaw, as described by Owen, but upon a fragment, evidently the posterior portion of the maxillary, and the teeth resemble the superior molars of some insectivorous forms.

Nearly all the mammals older than the Tertiary, judging from their dentition alone, may have lived mainly upon insects, with such accessory diet as modern Insectivores affect. The *Plagiaulacidæ*, however, show evidence of marked adaptation to some peculiar food, whether animal or vegetable cannot yet be determined with certainty. Now that the upper teeth of *Ctenacodon* are known, and trenchant teeth are found opposed to the lower cutting premolars, and tubercular molars to those below, the problem is simplified, but not solved. The evidence at present points to an animal, rather than to a vegetable, diet for all the *Allotheria*.

It is not improbable that there was a gradual change in diet in the later forms, until vegetable food predominated. The fact that the Tertiary genus *Neoplagiaulax*, Lemoine, has only a single lower premolar coincides with this view, and if *Hypsiprymnus* is a still later descendant, the additional molars, and other herbivorous features, may be the result of this gradual change.

The few Mammals known from the Trias may be placed in two families, *Dromotheridæ*, including the American specimens, and *Microlestidæ*, those of the old world. They are all quite distinct from any of the Jurassic forms, either those found in this country or in Europe. Below the Trias, no Mammals have hitherto been discovered; and none are known with certainty from the Cretaceous.

Mesozoic Mammals have very generally been referred hitherto to the *Marsupialia*. An examination of the known remains of American Mesozoic Mammalia, now representing upwards of two hundred distinct individuals, has convinced the writer that they cannot be satisfactorily placed in any of the present orders. This appears to be equally true of the European forms which the writer has had the opportunity of examining. With a few exceptions, the Mesozoic mammals best preserved are manifestly low generalized forms, without any distinctive Marsupial characters. Many of them show features that point more directly to Insectivores, and present evidence, based on specimens alone, would transfer them to the latter group, if they are to be retained in any modern order. This, however, has not yet been systematically attempted, and the known facts are against it.

In view of this uncertainty, it seems more in accordance with the present state of science, to recognize the importance of the generalized characters of these early mammals, as at least of ordinal value, rather than attempt to measure them by specialized

features of modern types, with which they may have little real affinity. With the exception of a very few, aberrant forms, the known Mesozoic mammals may be placed in a single order, which the writer has named *Pantotheria.** Some of the more important characters of this group are as follows:

(1.) Cerebral hemispheres smooth.
(2.) Teeth exceeding, or equalling, the normal number, 44.†
(3.) Canine teeth with bifid or grooved roots.†
(4.) Premolars and molars imperfectly differentiated.
(5.) Rami of lower jaw unankylosed at symphysis.
(6.) Mylohyoid groove on inside of lower jaw.
(7.) Angle of lower jaw without inflection.
(8.) Condyle of lower jaw near horizon of teeth.
(9.) Condyle vertical or round, not transverse.

The generalized members of this order were doubtless the forms from which the modern, specialized, Insectivores, at least, were derived.

Another order of Mesozoic mammals is evidently represented by *Allodon*, *Bolodon*, *Ctenacodon*, *Plagiaulax*, and a few other genera. These are all highly specialized, aberrant, forms, which apparently have left few, if any, descendants later than the Tertiary. This order, which the writer has termed the *Allotheria*,‡ can be distinguished from the previous group by the following characters:

(1.) Teeth much below the normal number.
(2.) Canine teeth wanting.
(3.) Premolar and molar teeth specialized.
(4.) Mylohyoid groove wanting.
(5.) Angle of lower jaw distinctly inflected.

These characters alone do not separate the *Plagiaulacidæ* and *Microlestidæ* from some of the Marsupials, and the facts now known seem to prove that they belong in that group, where they represent, at least, a well-marked sub-order.

Of the two families of Triassic Mammals now known, the *Dromotheridæ* may be placed in the order *Pantotheria*, and the *Microlestidæ*, in the *Allotheria*. According to present evidence, the former were probably placental, and the latter, non-placental, and marsupial.

* This Journal, vol. xx, p. 239, 1880.
† The genus *Paurodon* may be an exception.
‡ This Journal, vol. xx, p. 239, 1880.

The modern Placental mammals were evidently not derived from Marsupials, as is generally supposed. Each group has apparently come down to the present time, by separate lines, from primitive, oviparous, forms, of which, the living Monotremes may be the more direct but specialized representatives. Among the diversified members of Placental mammals, the Insectivores are probably the nearest to the early type, and hence they show many features seen in the Jurassic and Triassic mammals of the order *Pantotheria*.

Among the various existing Marsupials, the Rat-Kangaroos, (*Hypsiprymnidæ*) appear to be nearest to the oldest known forms represented in the order *Allotheria*, but future discoveries may, at any time, bring to light new Mesozoic mammals allied to other Marsupials.

So far as at present known, the two great groups of Placental and Non-placental mammals appear to be distinct in the oldest known forms, and this makes it clear that, for the primitive generalized forms (*Hypotheria*), from which both were derived, we must look back to the Palæozoic.

Yale College, New Haven, March 16, 1887.

EXPLANATION OF PLATES.

PLATE VII.

FIGURE 1.—Left upper jaw of *Allodon laticeps*, Marsh; outer view.

FIGURE 2.—The same specimen; seen from below.

FIGURE 3.—Left upper jaw of same species; inner view.

FIGURE 4.—The same specimen; seen from below.

FIGURE 5.—Left upper jaw of same species; outer view.

FIGURE 6.—The same specimen; seen from below.

FIGURE 7.—Right premaxillary of *Allodon fortis*, Marsh; outer view.

FIGURE 8.—The same specimen; seen from below.

FIGURE 9.—The same specimen; seen from in front.

FIGURE 10.—The same specimen; inner view.

FIGURE 11.—Portion of left upper jaw of *Allodon fortis*; outer view.

FIGURE 12.—The same specimen; seen from below.

FIGURE 13.—The same specimen; inner view.

FIGURE 14.—Lower incisor of *Allodon fortis*; side view.

FIGURE 15.—The same incisor; seen from in front.

a, last incisor; *a''*, second premolar; *b*, fourth premolar; *b'*, third premolar; *c*, second true molar; *c'*, first molar; *f*, antorbital foramen; *m*, malar arch; *s*, suture with maxillary.

Figures 1–4 are four times natural size; 5 and 6, six times natural size; 7–15, three times natural size.

PLATE VIII.

FIGURE 1.—Right lower jaw of *Ctenacodon serratus*, Marsh; outer view.

The small figure is natural size, and the larger one is magnified four diameters.

FIGURE 2.—Right upper jaw of *Ctenacodon potens*, Marsh; inner view.

FIGURE 3.—The same jaw; seen from below.

FIGURE 4.—Left lower jaw of *Ctenacodon serratus*; inner view.

FIGURE 5.—Incisor, probably of same species; seen from in front.

FIGURE 6.—The same incisor; seen from the side.

FIGURE 7.—Left lower jaw of *Ctenacodon potens*; outer view.

FIGURE 8.—The same jaw; inner view.

FIGURE 9.—The same jaw; front view, with its fellow restored in place.

In figures 2 and 3, *a'*, first premolar; *b*, fourth premolar; *c*, second molar; *m*, malar arch. In the lower jaws, *a*, incisor; *b*, condyle: *c*, coronoid process; *m*, molar; *r*, root of incisor; *s*, symphyseal surface.

Figures 2, 3, 5, and 6, are four times natural size, and figures 4, 7, 8, and 9, are three times natural size.

PLATE IX.

FIGURE 1.—Left lower jaw of *Stylacodon gracilis*, Marsh; outer view.

FIGURE 2.—Left lower jaw of *Dryolestes priscus*, Marsh; inner view.

FIGURE 3.—Left lower jaw of *Dryolestes vorax*, Marsh; outer view.

FIGURE 4.—The same jaw; inner view.

FIGURE 5.—Left lower jaw of *Laodon venustus*, Marsh; inner view.

FIGURE 6.—Left lower jaw of *Asthenodon segnis*, Marsh; anterior part, outer view.

FIGURE 7.—Right lower jaw of same species; outer view.

a, canine; *b*, condyle: *c*, coronoid process; *d*, angle; *g*, mylohyoid grove; *s*, symphyseal surface.

All the figures are three times natural size, except figure 5, which is four times natural size.

PLATE X.

FIGURE 1.—Right lower jaw of *Tinodon bellus*, Marsh; inner view.

FIGURE 2.—Right lower jaw of *Docodon striatus*, Marsh; inner view.

FIGURE 3.—Right lower jaw of *Diplocynodon victor*, Marsh; outer view.

FIGURE 4.—Right lower jaw of *Enneodon crassus*, Marsh; outer view.

FIGURE 5.—Left lower jaw of *Menacodon rarus*, Marsh; outer view.

FIGURE 6.—The same jaw; inner view.

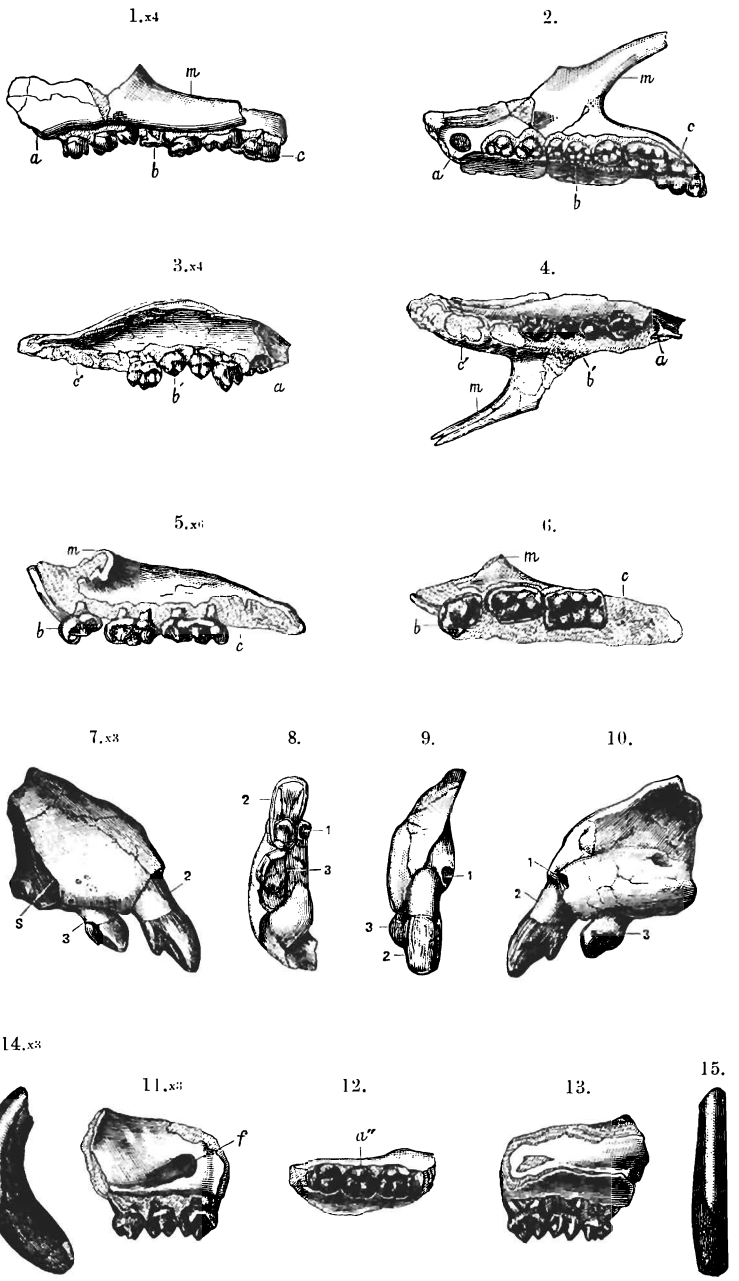
FIGURE 7.—Left lower jaw of *Paurodon valens*, Marsh; outer view.

FIGURE 8.—The same jaw; inner view.

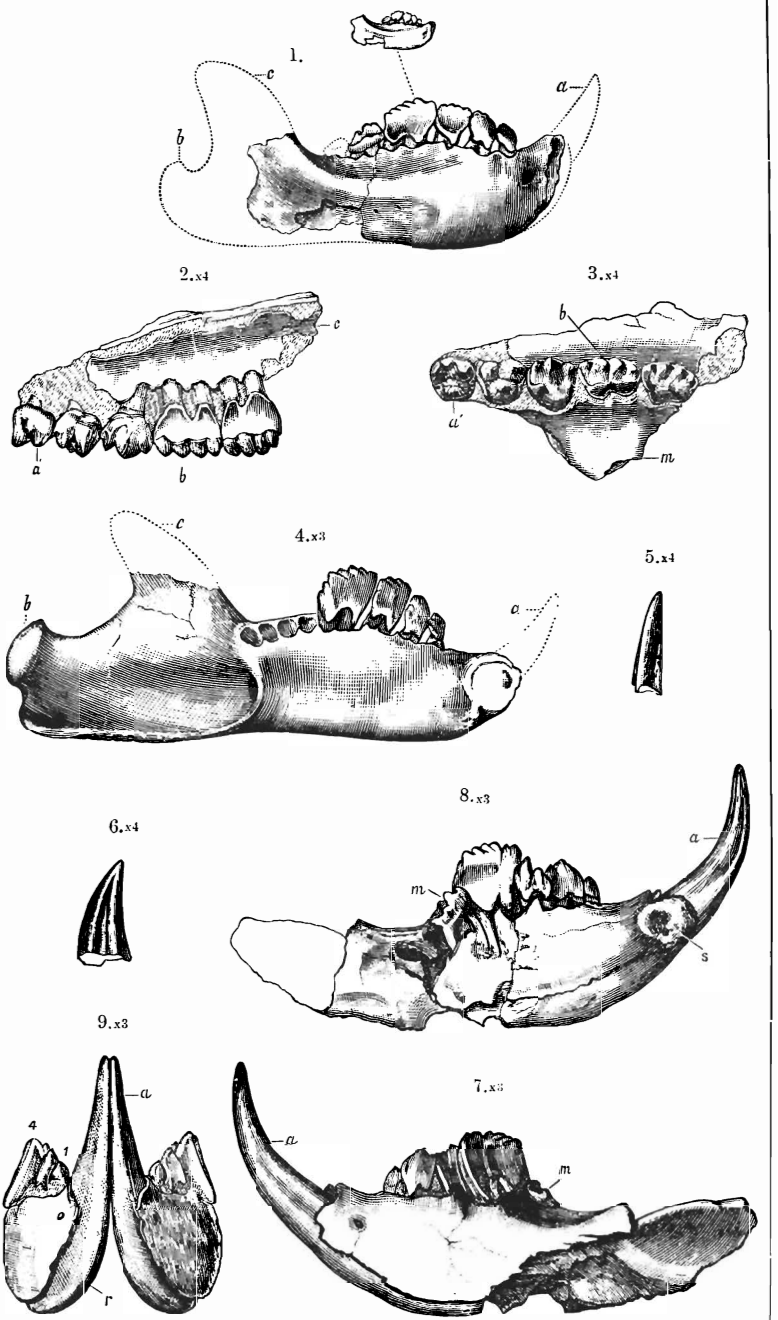
FIGURE 9.—Right lower jaw of *Priacodon ferox*, Marsh; inner view.

a, canine; *b*, condyle; *c*, coronoid process; *d*, angle; *f*, dental foramen; *g*, mylohyoid groove; *s*, symphyseal surface.

Figures 2 and 3 are twice natural size, and the others, three times natural size.



AMERICAN JURASSIC MAMMALS—ALLODON.



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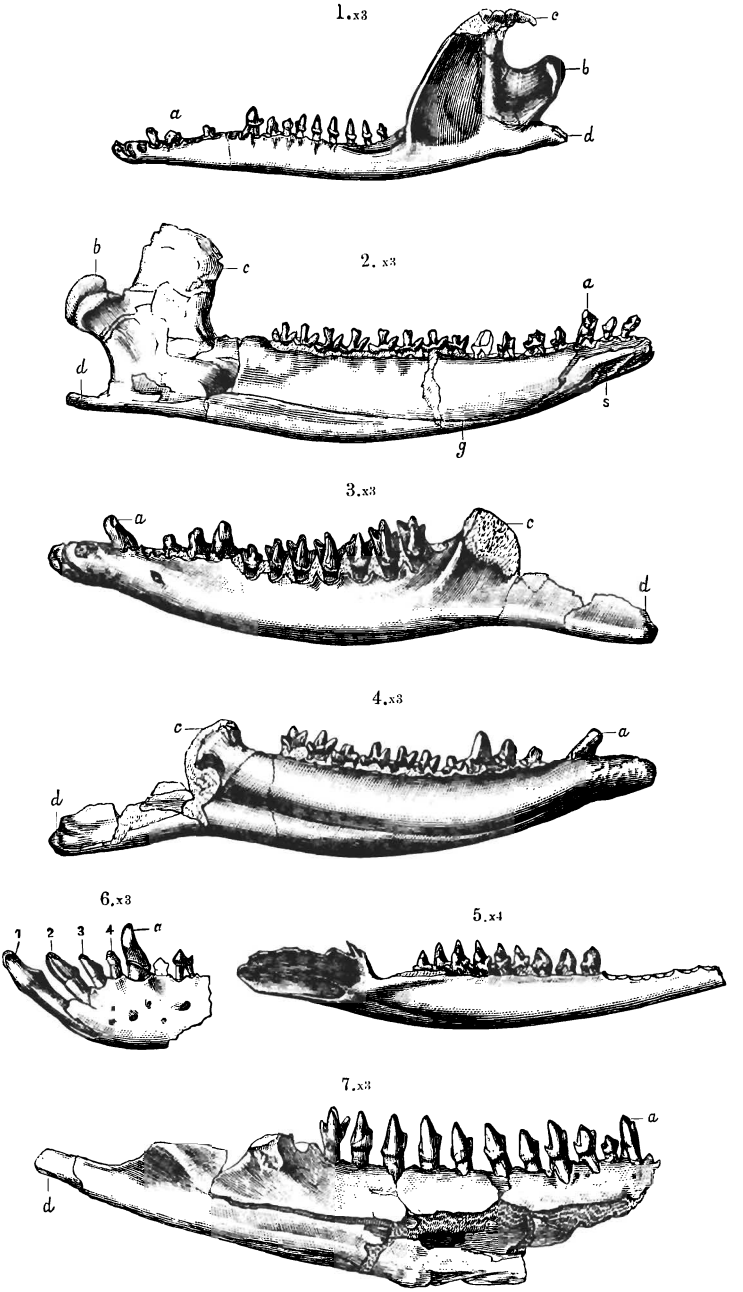

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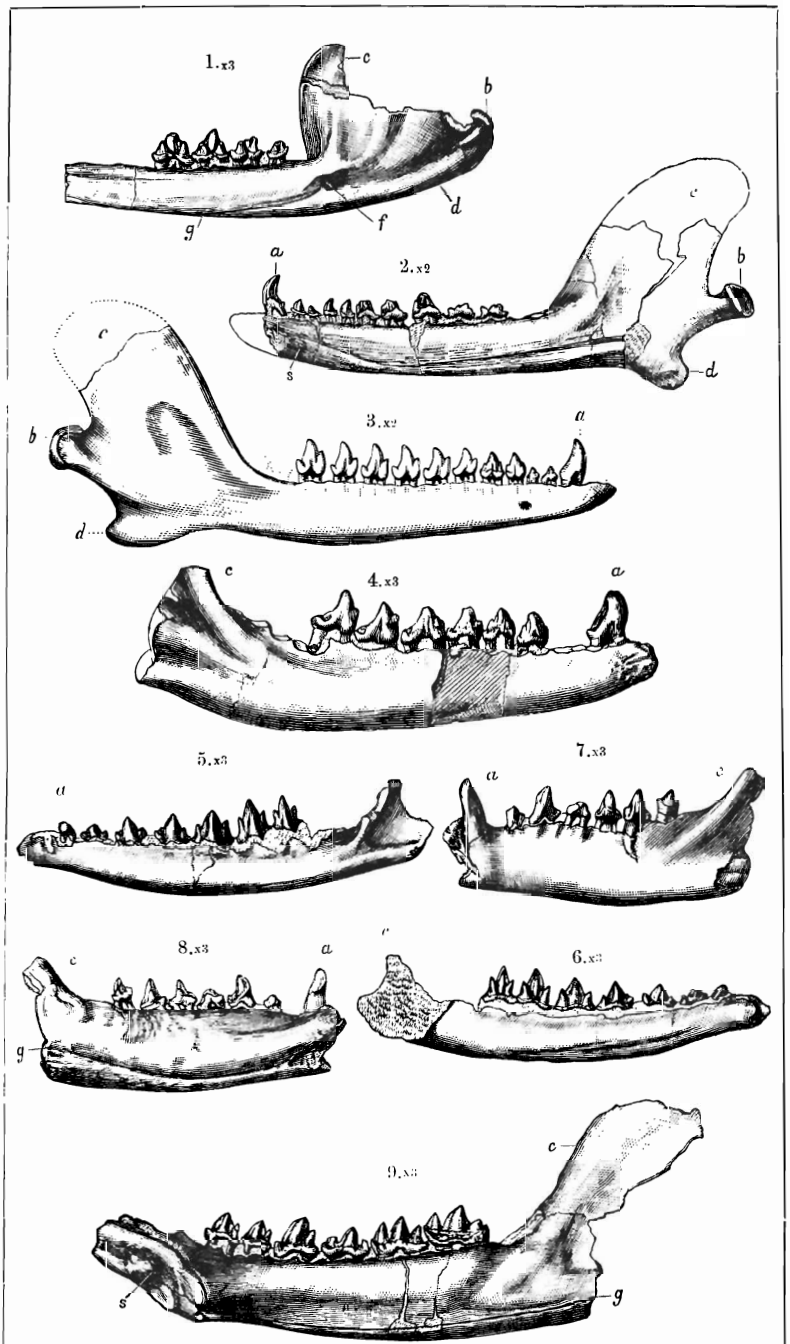

AMERICAN JURASSIC MAMMALS.