56.81,9(117:71.2)

Article VI.—THE FAMILY DEINODONTIDÆ, WITH NOTICE OF A NEW GENUS FROM THE CRETACEOUS OF ALBERTA

By W. D. Matthew and Barnum Brown

I.—INTRODUCTORY NOTE

This is the first of a series of preliminary notices to be published by Mr. Brown and myself to place upon record various contributions to a knowledge of the Cretaceous Dinosaurs resulting from the preparation of the collections secured in Alberta by the Museum parties of 1910 to 1915 under Mr. Brown's leadership. It had been planned that these results should be studied and published by him, but owing to his absence from the Museum for some years past, mostly on field work abroad, his researches have been long delayed. Some obvious preliminary results we have thought advisable to publish now, postponing the more complete research and publication of the material until Mr. Brown's return to the Museum enables him to resume his more intensive studies upon the several groups of Cretaceous dinosaurs.

As should appear from the situation above outlined, the junior author should be credited with the new evidence and data placed upon record, as the results of his splendidly successful series of expeditions in the Western Cretaceous formations. The senior author is chiefly responsible for the interpretation of the data, the revision of previous conclusions and taxonomy, and for various possible errors which will later be corrected in the extended researches planned by his absent friend and colleague, with whose approval and in the interest of the American Museum these contributions are placed upon record.—W. D. M.

II.—DISTINCTIVE CHARACTERS OF THE MEGALOSAURS, CŒLURIDS, ORNITHOMIMIDS AND DEINODONTS

As a result of twenty-four years work the American Museum has now on exhibition a magnificent series of skulls and skeletons which can be fully and directly compared. They are as follows:

MEGALOSAURIDÆ

Allosaurus, complete skeleton and two skulls, hind limbs, etc.

CŒLURIDÆ

Ornitholestes (=*Cœlurus*), skeleton.

ORNITHOMIMIDÆ

Struthiomimus, one complete and two incomplete skeletons.

DEINODONTIDÆ

Gorgosaurus (=*Deinodon*), three nearly complete skeletons, two skulls.

Albertosaurus (?=*Deinodon*), skull, hind limb, tail.

Tyrannosaurus, skeleton, skull, pelvis and hind limbs.

The above specimens are on exhibition, and the distinctive characters stated in the lists on the following pages can readily be checked up and verified by anyone visiting the hall. There are in addition many specimens prepared but not at present exhibited, notably two very good skeletons of *Allosaurus* and two of *Gorgosaurus*, a partial skeleton of *Tyranosaurus* and numerous less complete specimens of all the genera listed, and of others some of which are undescribed.

On the basis of this series the distinctive characters of these four groups can be clearly seen. The Deinodontidæ in particular can be adequately distinguished and their systematic position clarified.

1.—The Megalosaurid Group of the Jurassic

Megalosaurus—Allosaurus—Ceratosaurus

This group has been very fully described, so far as the American genera are concerned, by Mr. Gilmore in his highly authoritative and admirably written and illustrated memoir on the Carnivorous Dinosaurs in the U. S. National Museum.[1] While we fully agree with most of Mr. Gilmore's conclusions therein set forth, there are a few points on which, after careful consideration of his evidence and argument, we are unable to adopt his views. Among these differences are the inclusion of the deinodonts in the Megalosauridæ, the retention of the Ceratosauridæ as a separate family, and the dropping of the well-known name *Allosaurus* in favor of *Antrodemus*. The objections to these points of procedure will be stated later.

The characterization of this group as here given rests primarily upon *Allosaurus*, secondarily upon *Ceratosaurus*, both known from complete skeletons. *Megalosaurus*, although discovered nearly a century ago, is still imperfectly known and there are some peculiarities about the known parts that suggest that it is really not closely related to the American genera, and is an early stage in the evolution of the very extraordinary group from the Lower Cretaceous of North Africa that Strömer has recently characterized under the name of Spinosauridæ. The reference of the American genera to the Megalosauridæ we regard as provisional.

The characters of the group as thus based are:

1.—Moderate to large size and rather massive proportions.
2.—Skull relatively large, teeth large, jaw long and deep. Fenestræ large, arcades moderately heavy. Anterior teeth somewhat U-shaped, both crests tending to become posterior, unreduced in size.
3.—Quadrate loosely united to quadratojugal, rather short, extending strongly backwards as well as downwards.
4.—Considerable movement between frontal and parietal.
5.—Cervicals of moderate length.
6.—Fore limb moderately reduced, powerfully proportioned.
7.—Manus short and spreading with large powerful claws, the outer digits reduced and vestigial to a varying degree.
8.—Ungual phalanges of manus strongly curved, moderately compressed.
9.—Pelvic elements usually separate. Ilium high anteriorly with long and massive peduncle. Ischium with moderately heavy shaft, expanded distally into a massive thickened head.
10.—Tibia shorter than femur, pes rather short, massive or of moderate proportions.

[1]Gilmore, 1920, U. S. Nat. Mus. Bull. 110.

11.—Three subequal functional metatarsals, the shafts unreduced and not strongly appressed, of moderate length, the distal ends convex both ways. Digit I reduced to a distal vestige of the metatarsal, appressed against the shaft of mc. II with phalanges retroverted. Digit V a proximal splint.

12.—Phalanges of pes short and stout, the unguals moderately curved, uncompressed.

13.—Tail long, of many vertebræ, the distal caudals elongate, the prezygapophyses prolonged anteriorly.

Ceratosaurus differs from *Allosaurus* chiefly in four characters, the median frontal horn, the union of the metatarsals into a single bone, much as in the penguin, the union of the pelvic bones, and the decidedly less reduction of the external digits of the manus. The second and third characters do not involve any very marked difference in the form or proportions of the bones thus united and, while they may be characteristics of the genus and not merely of the individual due to age, yet they do not in our view involve any such wide osteological diversity as would warrant using them in family differentiation. The median horn of *Ceratosaurus* is a good generic distinction, but it is not at all likely that it would be a family character. The difference in the manus is the one really important distinction and here *Ceratosaurus* represents a decidedly more primitive stage in a line of specialization apparently somewhat different. As it is a contemporary of *Allosaurus*, this can be viewed partly as a structurally ancestral stage, partly as a divergent specialization, but it does not appear to us to be comparable to the diversity between *Ornitholestes*, *Struthiomimus*, and *Gorgosaurus*, which represent three distinct divergent lines of specialization in the manus. Taken all together, the differences between *Ceratosaurus* and *Allosaurus* do not appear to be more fundamental than those that distinguish *Deinodon* from *Tyrannosaurus*, *Monoclonius* from *Triceratops*, or *Corythosaurus* from *Trachodon*. They are of not more than sub-family value.

The substitution of *Antrodemus* for *Allosaurus* does not appear to be warranted at present, although future discovery of topotypes may prove it correct. *Antrodemus* is based upon an incomplete vertebral centrum, undoubtedly of a large theropod dinosaur from the "Morrison" formation of Middle Park, Colorado. No topotypes are known, and the vertebrate fauna from this vicinity is unknown. Without such topotype evidence we believe it is unsafe to conclude that the *Antrodemus* type is generically identical with *Allosaurus*. It may be provisionally so regarded, but a provisional reference is not sufficient ground to change the nomenclature. The type of *Allosaurus* is hardly more definitely determinable than that of *Antrodemus*, as Mr. Gilmore points out. But it is supported by adequate topotypes, among which is the fine skeleton

which Gilmore describes and figures so fully in his memoir. It seems better, therefore, to retain *Allosaurus* until adequate topotypes of *Antrodemus* have been obtained.

It is important to point out that in the differences between *Allosaurus* and *Ceratosaurus* we have apparently a guide to the tendencies of specialization in this family. The pes, as one would expect in a massively proportioned animal of this type, tends to consolidate the metatarsals into a single bone, stout and massive, the median element unreduced. This could not possibly lead into such a specialized type as is seen in the deinodonts and ornithomimids, which finds its analogy among rodents, marsupials, and birds in long, slender-footed, and comparatively small animals of leaping or cursorial adaptation. The manus, on the other hand, more specialized in *Allosaurus*, is a broad, short, spreading affair, not at all reduced in relative size compared with that of *Ceratosaurus* and having an important prehensile function. The further specialization here would tend apparently to two widely divergent, grasping digits on a moderately large and very powerful limb. The clue to the derivation of the deinodont manus may be found in either the megalosaurid or cœlurid type, but only through a marked reduction in size, which would hardly be expected in gigantic predaceous beasts and is not indicated in the megalosaurs. The tail of the megalosaurids is primitive but shows conditions that might lead into the peculiar specialization seen in the cœlurids, deinodonts and ornithomimids. Perhaps the most significant differences are seen in the pelvis, which in the deinodonts is very much nearer to the cœlurid and ornithomimid type than it is to the megalosaurid construction. The megalosaurs are nearer the sauropoda in their pelvic construction than are the other three families. On the other hand, there are no very obvious characters in the skull of the megalosaurs, which would preclude regarding them as the primitive ancestral group from which the deinodonts were derived.

2.—The Cœlurid Group of the Jurassic
Ornitholestes and *Cœlurus*

Mr. Gilmore has given very strong reasons for regarding *Ornitholestes* as a synonym of *Cœlurus*, and there can be no doubt that they are closely related. The characters of the cœlurid group can, therefore, be defined from *Ornitholestes*, and its status and affinities estimated.

The redescription by Osborn[1] presents the principal characters:

[1]Osborn, 1917, Bull. Amer. Mus. Nat. Hist., XXXV, pp. 733–771.

1.—Small size and slender proportions.
2.—Skull relatively small, teeth small, compressed, the premaxillary teeth somewhat reduced and of U-shaped cross-section. Jaw short, not deep.
3.—Quadrate closely sutured to quadratojugal, elongated, and extending forward and downward (owing to reduced relative length of jaw).
4.—No fronto-parietal movement.
5.—Cervicals long and slender.
6.—Fore limb not greatly reduced, bones long and slender throughout.
7.—Manus peculiarly specialized, mc. I very short and stout, divergent, mc. II and III long, slender, parallel, III greatly reduced in diameter; distal ends of metacarpals heavily grooved. All phalanges very long and slim. The metacarpals have the same proportions as in *Allosaurus* but the phalanges are of wholly diverse type.
8.—Ungual phalanges of manus greatly compressed, strongly curved.
9.—Pelvic bones united. Ilium elongate, extended far forward and decurved anteriorly, without distinct peduncle. Ischia slender, long, flattened distally but not expanded.
10.—Tibia somewhat longer than femur, pes very long and slender, isotridactyl.
11.—Three long slim metatarsals, separate, somewhat appressed, median metatarsal not reduced proximally, vestigial 1st and 5th digits unknown, probably as in Megalosauridæ.
12.—Ungual phalanges of pes of moderate length and curvature, not compressed.
13.—Tail elongate, not fully known but the distal caudals appear to be interlocked by prolongation anteriorly of the prezygapophyses.

The complete knowledge of the ornithomimid type shows that "*Ornitholestes*," as is recognized by Osborn (1917, p. 733), can no longer be understood as ancestral to it. This is especially seen in the fore limb, which is quite as much specialized but in a different manner. Nor is there anything in the pes that especially suggests an ancestral stage of the peculiarly specialized ornithomimid pes, which, as Gilmore has shown, had already appeared in the Lower Cretaceous. It is none the less true that, except for the fore limb, we might regard *Cœlurus* as not far from the ancestral type and that it may be considered as a collateral, although clearly not a direct ancestral, stage. But it would seem better to retain it in a separate family (Cœluridæ) for the present.

As compared with *Compsognathus*, *Cœlurus* is much more specialized. The Solenhofen skeleton shows, besides the three functional digits on the pes, a moderately reduced first and a vestige of the fifth; the manus has also three functional and two vestigial digits. The pubis is broad, the ischium very slender; many other details would no doubt show the far more primitive character of this little dinosaur. While it may be ancestral structurally to *Cœlurus*, no especial evidence is apparent in *Compsognathus* of the specializations peculiar to the cœlurid group and, again, being not far from contemporary it cannot be a direct ancestor.

Its relations to the megalosaurs are not very close, and it seems better to hold it as the type of a distinct family, Compsognathidæ.

3.—The Ornithomimid Group of the Cretaceous

Cœlosaurus, Ornithomimus, and *Struthiomimus*

It will hardly be open to question that these three genera form a closely allied natural group. Whether they should or should not be held distinct is at present a matter of opinion. The family may be characterized on the basis of the *Struthiomimus* skeleton described by Osborn as follows:

1.—Moderate size and slender proportions.
2.—Skull relatively small, toothless, orbital fenestra very large, jaw short and shallow.
3.—Quadrate closely sutured to quadratojugal, elongated, extending forward and downward.
4.—Unknown.
5.—Cervicals very long and slender.
6.—Fore limb slender but much elongate throughout.
7.—Manus peculiarly specialized, mc. I–III of equal length and thickness, mc. I divergent at distal end, appressed medially to mc. II, mc. III parallel but not appressed, phalanges greatly elongate. Distal ends of metacarpals all with convex heads.
8.—Ungual phalanges of manus moderately compressed, elongate, not strongly curved.
9.—Pelvic bones united. Ilium without peduncle, elongate and decurved anteriorly, ischium long, slender, flattened and decurved, moderately expanded at tip.
10.—Tibia longer than femur, metatarsals long, phalanges of moderate proportions.
11.—Metatarsals II and IV long, slim, subequal, median metatarsal broader at distal end but the shaft greatly reduced in the distal portion, trigonal, the inferior sides closely appressed to the lateral metacarpal shafts, in the proximal portion reduced to little more than a thread, partly concealed between the lateral shafts; the head a little enlarged but enclosed dorsad and plantad by the much larger heads of the lateral metatarsals. The distal ends of the lateral metatarsals are convex both ways, that of the median plano-convex. Vestigial 1st and 5th metatarsals as in Megalosauridæ, but further reduced or sometimes ? absent.
12.—Phalanges of pes of moderate length, the unguals rather short and not strongly curved or compressed.
13.—Tail elongate, the distal caudals strongly interlocked by prolongation of the postzygapophyses.

Cœlosaurus antiquus Leidy

Types.—(1) A complete tibia. Described and figured by Leidy, 1865, Smithsonian Contrib., 192, p. 100, Pl. III, fig. 3. (2) Proximal and distal ends of tibia, distal end of lateral metatarsal, median and lateral proximal phalanges, all of one individual. Described and figured

by Leidy, *ibid.*, p. 101, Pl. XVII, figs. 6–11. Cope in 1868 referred the second specimen to "*Lælaps*," under the name of *L. macropus*. In the light of present knowledge it appears more probable that Leidy's original reference should be sustained.

HORIZON AND LOCALITY.—Cretaceous greensands of New Jersey from Burlington and Monmouth Co. respectively.

So far as one can judge from the types, it would appear that this genus is closely allied to *Struthiomimus* Osborn and *Ornithomimus* Marsh, and perhaps identical with one or both. The type specimens are hardly less characteristic than the type of *Ornithomimus* and, if *Struthiomimus* is to be abandoned, as Gilmore advocates, on the ground that no adequate generic distinctions from *Ornithomimus* have been shown to exist, it would seem that the logical procedure would be to abandon both genera in favor of *Cœlosaurus*, on the ground that there is no known distinction at all between them. At all events, it would appear that Gilmore's ornithomimid bones from the Maryland Cretaceous could with somewhat better probability be referred to Leidy's genus than to the Western *Ornithomimus*, typically of much later age than the Arundel and later than the Jersey greensands.

4.—THE DEINODONT GROUP OF THE CRETACEOUS

Deinodon, including *Gorgosaurus* and *Albertosaurus*; *Dryptosaurus*; *Tyrannosaurus*, including *Dynamosaurus*

This group includes the large Upper Cretaceous dinosaurs. *Gorgosaurus* and *Albertosaurus* are very probably identical with *Deinodon*, and *Dynamosaurus* with *Tyrannosaurus*. *Dryptosaurus* is provisionally held distinct from *Deinodon*, which it much resembles. The essential features of this group are:

1.—Gigantic size and massive proportions.

2.—Skull relatively large with long deep jaw and large teeth. All fenestræ more or less reduced and arcades massive. Anterior teeth of U-shaped cross-section, (both crests posterior) the form changing progressively to the compressed oval section of the posterior teeth, with anterior and posterior serrate crest. Premaxillary teeth in the above genera much reduced in size.

3.—Quadrate closely united to quadratojugal, elongate, extending backward and downward.

4.—No fronto-parietal movement.

5.—Cervicals short and wide.

6.—Fore limb greatly reduced in relative size, moderately slender throughout.

7.—Manus peculiarly specialized, mc. I very short and stout, mc. II much longer, mc. III vestigial, distal ends of metacarpals deeply grooved, phalanges rather short.

8.—Ungual phalanges of manus strongly curved and much compressed.

9.—Pelvic bones usually solidly united. Ilium elongate, extended far forward and decurved anteriorly with very short peduncle, ischium flattened distally and decurved, not expanded at the tip.

10.—Tibia and femur of subequal length, pes stout and massive and of moderate length.

11.—Lateral metatarsals massive, moderately long, median metatarsal broader than either at distal end, but the shaft greatly reduced, in the distal portion trigonal, the inferior sides closely appressed to the lateral metatarsal shafts, in the proximal portion reduced to a very slender rod between the lateral shafts; the head a little enlarged but enclosed dorsad and plantad by the large heads of the lateral metatarsals. The distal ends of the lateral mestarsals are convex both ways, that of the median plano-convex

12.—Phalanges of pes massive and rather short, the unguals moderately curved, uncompressed.

13.—Tail elongate, the distal caudals strongly interlocked by prolongation of the prezygapophyses.

The above analysis of characters shows that the deinodonts, although paralleling the megalosaurs in their huge size, massive proportions, short neck and large head, differ from them and resemble the cœlurids and ornithomimids in the construction of the pelvis and the elongate quadrate. The pes has the very peculiar and specialized character of the Ornithomimidæ very exactly reproduced, save for the greater massiveness of all its elements; the manus is nearer to that of the Cœluridæ in some respects than to the megalosaurs, despite the diversity in the length of the phalanges, but might almost equally well be regarded as a specialization from that of *Allosaurus*. A review of the characters indicates that this group is not derived from the megalosaurs but from some primitive cœlurosaurian with the specialized pes of the Ornithomimidæ, but with the fore limb constructed more as in Cœluridæ or in *Allosaurus*, although smaller and with the phalanges less elongate than in *Cœlurus*. Such a type would probably be a slender, small, swift-footed animal, for only in such a type can one understand the evolution of the remarkable specialization of the pes. The subject of the affinities and origin of the various groups of theropod dinosaurs will be ably and thoroughly discussed in an essay by Doctor von Huene to be published elsewhere, and the foregoing data, based upon comparison of the theropod skeletons on exhibition in the American Museum, are intended only to present the reasons for the taxonomic arrangement here adopted.

The point which we principally desire to make clear is that upon the above evidence the Deinodontidæ must be regarded as a distinct and well-characterized family paralleling the megalosaurs but not derived from them, and that they cannot be included in that family as has been the general custom.

III.—CHRONOLOGICAL LIST OF AMERICAN CRETACEOUS DEINODONTS AND ORNITHOMIMIDS

NAME AS ORIGINALLY PROPOSED, AUTHOR AND DATE	FORMATION AND LOCALITY	NATURE OF TYPE OR CO-TYPES	PRESENT REFERENCE
Deinodon horridus Leidy, 1856	Judith R., Mont.	teeth	*Deinodon horridus*
Cœlosaurus antiquus Leidy, 1865	Greensand, N. J.	tibia, foot bones	*Cœlosaurus antiquus*
Lælaps aquilunguis Cope, 1866	" "	parts of skeleton	*Dryptosaurus aquilunguis*
" *macropus* Cope, 1868	" "	foot bones, etc.[1]	*Cœlosaurus* (?) *antiquus*
Fam. Dinodontidæ Cope, 1866			Deinodontidæ
Aublysodon mirandus Leidy, 1868	Judith R., Mont.	teeth	= *Deinodon horridus*
Lælaps explanatus, Cope, 1876	" "	"	= (?) *Dromæosaurus* sp.
" *falculus* Cope, 1876	" "	"	= "
" *incrassatus* Cope, 1876	" "	"	= *Deinodon* (?) *horridus*
Aublysodon lateralis Cope, 1876	" "	"	" "
Lælaps cristatus Cope, 1877	" "	"	?*Dromæosaurus cristatus*
" *hazenianus* Cope, 1877	" "	"	= *Deinodon* (?) *horridus*
" *lævifrons* Cope, 1877	" "	"	*Dromæosaurus lævifrons*
Zapsalis abradens Cope, 1877	" "	tooth	Incertæ sedis, cf. *Dromæosaurus*
Dryptosaurus Marsh, 1877, type *Lælaps aquilunguis*			*Dryptosaurus*
Allosaurus medius Marsh, 1888	Arundel, Md.	tooth	(?) *Dryptosaurus medius*
Cœlurus gracilis Marsh, 1888	" "	"	(?) *Dromæosaurus gracilis*

[1]Co-type of *Cœlosaurus antiquus*.

Ornithomimus velox Marsh, 1890	Denver, Colo.
" *tenuis* Marsh, 1890	Judith R., Mont.
" *grandis* Marsh, 1890	" "
Fam. Ornithomimidæ Marsh, 1890	
Fam. Dryptosauridæ Marsh, 1890	
Ornithomimus sedens Marsh, 1892	Lance, Wyo.
" *minutus* Marsh, 1892	Denver, Colo.
Aublysodon amplus Marsh, 1892	Lance, Wyo.
" *cristatus* Marsh, 1892	" "
Manospondylus gigas Cope, 1892	Lance, S. Dak.
Dryptosaurus kenabekides Hay, 1899	Judith R., Mont.
Ornithomimus altus Lambe, 1902	Belly R., Alberta
Tyrannosaurus rex Osborn, 1905	Hell Cr'k, Mont.
Dynamosaurus imperiosus Osborn, 1905	Lance, Wyo.
Albertosaurus sarcophagus Osborn, 1905	Edmonton, Alta.
Fam. Tyrannosauridæ Osborn, 1906	
Gorgosaurus libratus Lambe, 1914	Belly R., Alta.
Struthiomimus Osborn, 1917, type *O. altus* Lambe, topotype a complete skeleton	
Ornithomimus affinis Gilmore, 1920	Arundel, Md.

pes	*Ornithomimus velox*
? metatarsal III	*Struthiomimus tenuis*
? "	*Deinodon* (?) *horridus*
	Ornithomimidæ
	=Deinodontidæ
part skeleton	*Ornithomimus sedens*
(?) metapodial	Indeterminate
tooth	=(?) *Tyrannosaurus* sp.
"	" "
two vertebral centra	Indeterminate
teeth	=*Deinodon horridus*
hind limb	*Struthiomimus altus*
part skeleton	*Tyrannosaurus rex*
" "	=*Tyrannosaurus rex*
skull	(?) *Deinodon sarcophagus*
	=Deinodontidæ
skeleton	(?) *Deinodon libratus*
	Struthiomimus
foot bones	(?) *Cœlosaurus affinis*

	Comanchic or Lower Cretaceous	Upper or True Cretaceous					
	Barrémian-Urgonian	Upper Senonian			Danian		
	Arundel Md.	Judith R. Montana	Belly R. Alberta	Upper Greens'd N. J.	Edmonton Alberta	Lance Wyo., Mont.	Denver Col.
Suborder Goniopoda Cope (Theropoda Marsh in part).....							
1. Family Deinodontidæ Cope							
a. Subfamily Deinodontinæ (Dryptosauridæ Marsh)							
Deinodon horridus Leidy.....	.....	×					
Dryptosaurus aquilunguis (Cope).....	.....	.....	.....	×			
" *medius* (Marsh).....	×	.....	.....	.....	.....	.....	.....
Gorgosaurus libratus Lambe.....	.....	.....	×	.....	.....	.....	.....
" *sternbergi*, new species.....	.....	.....	×	.....	.....	.....	.....
Albertosaurus sarcophagus Osborn.....	.....	.....	.....	.....	×	.....	.....
b. Subfamily Tyrannosaurinæ Osborn							
Tyrannosaurus rex Osborn.....	.....	.....	.....	.....	.....	×	.....
c. Subfamily Dromæosaurinæ							
Dromæosaurus albertensis.....	.....	.....	×	.....	.....	.....	.....
" *lævifrons* (Cope).....	.....	×	.....	.....	.....	.....	.....
? " *cristatus* (Cope).....	.....	×	.....	.....	.....	.....	.....
?*Zapsalis abradens* (Cope).....	.....	×	.....	.....	.....	.....	.....
?*Dromæosaurus gracilis* (Marsh).....	×	.....	.....	.....	.....	.....	.....
2. Family Ornithomimidæ Marsh							
Cœlosaurus antiquus Leidy.....	.....	.....	.....	×	.....	.....	.....
? " *affinis* Gilmore.....	×	.....	.....	.....	.....	.....	.....
Struthiomimus altus (Lambe).....	.....	.....	×	.....	.....	.....	.....
" *tenuis* (Marsh).....	.....	×	.....	.....	.....	.....	.....
Ornithomimus velox (Marsh).....	.....	.....	.....	.....	.....	.....	×
" *sedens* (Marsh).....	.....	.....	.....	.....	.....	×	.....

IV.—Provisional Systematic Arrangement

In the table opposite the indeterminate types and synonyms are omitted; a number of genera of very doubtful validity are provisionally retained, and a number of provisional allocations of species and genera are marked with a query.

V.—Remarks upon the Nomenclature of the Deinodontidæ

It should first be pointed out that Cope's name Dinodontidæ was the first family name to be applied to a carnivorous dinosaur. It antedates Megalosauridæ by four years and is based upon an unquestionably valid genus. But there is no need to discuss whether or not it should be used in place of Megalosauridæ—as it should, according to the usage of many palæontologists[1]—for the two families appear to be distinct.

Cope's original characterization of the family Deinodontidæ[2] was as follows: ". . . . The family Dinodontidæ . . is characterized by its contractile, raptorial claws and slender digits, and compressed sabre-shaped teeth." This definition was intended to distinguish the family from the herbivorous dinosaurs. The family Megalosauridæ was proposed by Huxley four years later.

Marsh[3] characterized the "Dryptosauridæ" as follows: "Including the large carnivorous forms of which only imperfect specimens have been found but sufficient to indicate that they are distinct from the Megalosauridæ of the European Jurassic. Limb bones hollow. Fore limbs very small. Feet digitigrade with prehensile claws." The Ornithomimidæ he characterized at the same time, referring them to the Ornithopoda (=Iguanodontia): "Limb bones hollow. Fore limbs very small; hind limbs of avian type. Feet digitigrade and unguiculate." Two years later[4] he transferred them to the Theropoda. In 1895[5] he somewhat expanded his definition of the Dryptosauridæ as distinct from the Megalosauridæ, but there is nowhere any reference to the Deinodontidæ or indication of the position to which he assigned the genus *Deinodon*. It may be assumed that he accepted Cope's mistaken conclusion that the generic name was preoccupied and the family name therefore untenable.

In this connection it may be well to call attention to the fact that Cope in 1866[6] divided the Dinosauria into two primary (subordinal) groups:

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[1] *Vide* discussion in Palmer's 'Index Generum Mammalium.'
[2] Cope, 1866, Proc. Acad. Nat. Sci. Phila., XVIII, p. 279.
[3] Marsh, 1890, Amer. Journ. Sci., XXXIX, p. 424.
[4] Marsh, 1892, Amer. Journ. Sci., XLIII, p. 451.
[5] Marsh, 1895, Amer. Journ. Sci., L, p. 493.
[6] Proc. Acad. Nat. Sci. Phila., XVIII, p. 317.

1. Goniopoda; types, *Lælaps* and probably *Megalosaurus.*

2. Orthopoda; types, *Scelidosaurus, Hylæosaurus, Iguanodon,* and *Hadrosaurus.*

He subsequently[1] added *Cœlosaurus* Leidy and *Poikilopleuron* Deslongchamps to the Goniopoda, but excluded *Compsognathus,* referring it to a third group, the Symphypoda. The distinctions lay in the characters of the tibio-tarsal joint. *Megadactylus* (*Anchisaurus*) he tentatively associated with the Symphypoda, of which the types are *Ornithotarsus* Cope 1869 (which? = *Hadrosaurus*) and *Compsognathus.* (This very unnatural association is based upon the supposed anchylosis in both of the astragalus with the tibia.)

It would appear, therefore, that Cope's suborder Goniopoda includes the families Deinodontidæ, Megalosauridæ and Ornithomimidæ, as represented by the genera then known.[2] It differs from Marsh's Theropoda in that it excludes the Triassic dinosaurs. It may prove to be a tenable and useful group name.

Orthopoda is clearly delimited to cover what was then known of the ornithischian dinosaurs and considerably antedates both *Ornithischia* Seeley and *Predentata* Marsh.

The Symphypoda includes *Compsognathus* and the Triassic dinosaurs (we may omit *Ornithotarsus* as a very fragmentary type whose position was misunderstood).

Now, it is a point of interest that Cope's instinct for comparative anatomy had enabled him to sense the real affinities of the various types of dinosaurs even though he was unable to define them; for the stated distinctions between these groups are worthless. But his arrangement of 1868 is a better one than Marsh's classification, made twenty years later and based upon vastly better material.

A few further notes appear to be necessary to defend the ordinal and subordinal terms used in this connection.

1.—DINOSAURIA Owen, 1842, was based upon *Iguanodon* and *Megalosaurus,* i.e., upon representatives of both the saurischian and ornithischian divisions, which are now regarded as distinct orders. It cannot, therefore, according to the customs of nomenclature, be limited to the Saurischia as Abel has recently suggested.[3] It must be used to cover

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[1]Cope, 1868, Journ. Acad. Nat. Sci. Phila., XIV, p. 100.

[2]Also *Poikilopleuron,* which is regarded by von Huene as related to the plateosaurs; but Cope's inclusion of this genus, if based on Deslongchamps' description, must have been wholly provisional and did not really affect his concept of the group.

[3]Abel, 1916, Naturwiss. Woch., XXXII, p. 469–474. The rule regarding names of groups of higher than family rank is as follows: "La loi de priorité est applicable aux noms de familles *ou de groupes plus élèves,* tout aussi bien qu'aux noms de genres et d'espèces *à la condition qu'il s'agisse de groupes ayant même extension.*" International code, 1892. The A. O. U. code has substantially the same provision regarding scope. If the law of priority is to prevail in groups of higher than family rank on the condition that the group names have exactly or substantially the same scope, it is obvious that it is not permissible to alter radically the scope of such terms; nor does zoölogical usage sanction such alterations, although it does not appear to be directly forbidden by the codes.

substantially what it was proposed to cover, and to limit the term Dinosauria Owen to the Saurischia would be to remove the major part of what he included under it (*Iguanodon*, etc.) and limit it to the minor part (*Megalosaurus*), plus a group (Opisthocœlia=Sauropoda), which he included under another order (Crocodilia). Abel's proposal appears to be technically improper and very undesirable, because it is very convenient to retain the term Dinosauria, although NOT as an ordinal name but as a convenient term to cover the whole group of reptilia to which it has been customarily applied, and which have a good deal in common although now fully recognized as pertaining to two distinct orders. As thus used, "dinosaurs" would be largely analogous to "pachyderms" among the mammals, a most useful term although not now understood as an ordinal one.

2.—SAURISCHIA Seeley appears to be the first and only name that has been proposed to cover the two groups currently known as Theropoda and Sauropoda, and which, as has been most fully demonstrated by von Huene, require ordinal separation from the ornithischian group.

3.—Seeley's ORNITHISCHIA, while an admirable correlative term for Saurischia, is antedated by Cope's Orthopoda with the same scope. Seeley's term antedates Marsh's Predentata, which is in current use and, like Seeley's term, admirably descriptive of an essential character of the entire group.

4.—In the subordinal grouping of the Saurischia, Marsh's arrangement has been shown by von Huene and others to be an unnatural one. We do not altogether accept von Huene's view that the primary division is into Cœlurosauria and Pachypodosauria, nor on the other hand does Jaekel's arrangement of Therophagi and Allophagi, the latter equalling Sauropoda+Plateosauridæ, the former including all the rest, appear to be very satisfactory. The fact appears to be that all the Triassic dinosaurs share in common a series of characters, which while doubtless mostly primitive, are quite clearly diagnostic, and separate them from the specialized groups of the later Mesozoic. Of the latter, the Sauropoda can in practice be most clearly set off as a group apart; the remainder (Megalosauridæ, Spinosauridæ, Cœluridæ, Deinodontidæ, Ornithomimidæ) might be united under Cope's term Goniopoda, if von Huene's more phyletic classification is not sustained. Where we know so little about the true phylogeny as with the dinosaurs it seems advisable to be conservative and base our classification upon concrete facts of structural characters more than upon somewhat conjectural views as to phyletic relations. Such procedure will be more likely to make for permanency in the nomenclature.

Deinodon Leidy, 1856, had for genotype *D. horridus* of the Judith River, Montana. This was the first genus of the Upper Cretaceous carnivorous dinosaurs to be described. It is based upon a number of more or less fragmentary teeth, figured by Leidy in his memoir on the Judith River. Leidy originally regarded them as all belonging to the same species, but subsequently adopted Cope's suggestion that those of U-shaped cross-section were of a different genus, which Leidy named *Aublysodon*. Cope rejected the name "*Dinodon*" as a homonym of *Dinodus*—which it is not; the derivation of the two words is different—and proposed *Lælaps*, which is a preoccupied name, for the lenticular or oval-sectioned teeth, with *L. aquilungius* of New Jersey as type. Marsh substituted *Dryptosaurus* for the preoccupied name *Lælaps* and added a couple more species of "*Aublysodon*" in 1892. Hay in 1899 pointed out that Cope had restricted the name *Deinodon* to the U-shaped teeth before Leidy gave the name *Aublysodon* to these teeth. *Aublysodon* therefore, cannot be applied to these teeth. Since it now appears that both types of teeth belonged to one animal, this all becomes unimportant and needs no further discussion.

The original idea of Leidy was that the U-shaped teeth were in the front of the jaw. Cope, however, believed that the lower jaw of his *L. aquilunguis* did not have that kind of teeth in front, hence the conclusion, shared by Leidy and Marsh, that the U-shaped teeth were a distinct type. When Marsh secured complete skulls of megalosaurians from the Morrison, it was evident that the upper front teeth approached this type to some degree, but they are by no means so sharply contrasted in size and form with the maxillary and dentary teeth as are the teeth of *Deinodon*. Marsh as late as 1892 regarded them as distinct.

Skulls from the Edmonton of Canada were described by Cope in 1892 and subsequently more fully described by Lambe in 1904, but these still failed to show the characters of the premaxillary teeth. In 1905 Osborn described the gigantic *Tyrannosaurus* and "*Dynamosaurus*" of the Lance and distinguished them primarily by large humerus ascribed to the one and dermal plates to the other.[1] Osborn in this paper excludes from "*Deinodon*" the small U-shaped teeth figured by Leidy, but recognizes the large U-shaped teeth as "premaxillary and premandibular." Lambe in describing *Gorgosaurus* follows Osborn in this restriction and distinguishes *Gorgosaurus* from *Deinodon* by the posses-

[1]Both these distinctions were then as now believed to be erroneous by Matthew, as may be seen in his restoration of the skeleton published by Osborn (Fig. 1, *loc. cit.*) and the first has since been definitely abandoned and *Dynamosaurus* recognized as a synonym of *Tyrannosaurus*.

sion in the premaxilla of just such teeth as are thus excluded from the type of *Deinodon!* The fact is, of course, that the "*Gorgosaurus*" skulls from the Red Deer River show that the large U-shaped teeth are anterior dentary, the small U-shaped teeth premaxillary, and the oval and compressed teeth posterior maxillary and mandibular teeth of the same genus, just as Leidy provisionally regarded them in his original description of *Deinodon*.

There is, therefore, nothing in the dentition to separate *Gorgosaurus* from *Deinodon* and they are unquestionably nearly related and, so far as the teeth are concerned, would appear to be the same genus. But, pending the discovery of adequate topotypes from the Judith River beds, the identity has not been finally and conclusively proven. There may be differences in the skull. Certainly, in comparison with the very distinct generic differences that separate both from *Tyrannosaurus*, they fall very clearly into the same group.

Marsh's name *Dryptosaurus* may in an equally provisional way be retained for the New Jersey Cretaceous *D. aquilunguis*. *Lælaps* must be abandoned as a preoccupied name, *Aublysodon* as a synonym of *Deinodon*.

Osborn has already (1917) called attention to another fragmentary type, *Manospondylus gigas*, as possibly identical with *Tyrannosaurus* but based upon an inadequate type. It may further be noted that Marsh described the feet of *Tyrannosaurus* and its allies, referring them to *Ornithomimus* under the name of *O. grandis*. The type of this species is from the Judith, and is probably correctly referred by Gilmore (1920, p. 122) to *Deinodon*. Referred specimens from the Lance are more probably *Tyrannosaurus*, as referred by Gilmore (*loc. cit.*).

Cope referred to "*Lælaps*" and "*Aublysodon*" a number of quite small species known only from isolated teeth, some of which probably belong to the genus here described.

VI.—A New Genus of Carnivorous Dinosaurs from the Cretaceous of Alberta

Dromæosaurus albertensis, new genus, new species

Type.—A. M. No. 5356, skull and lower jaws, and a few foot bones.

Horizon and Locality.—Belly River formation, Red Deer River, Alberta. Found by Barnum Brown, Amer. Mus. Exped., 1914.

Generic Diagnosis.—

Comparable in size with *Ornithomimus*. Dental formula $\frac{\text{Pmx. ? 3; Max. 9}}{\text{Den. 10}}$

Teeth well developed, asymmetrically oval or compressed, sharp-pointed, recurved, serrate on anterior and posterior border. Premaxillary teeth three or more, not reduced in size, strongly convex antero-externally but not of fully U-shaped section. Posterior teeth similar but more compressed and blade-like in both upper and lower jaw, the last maxillary tooth small. Jaws elongate, not massive. Orbital fenestra larger proportionately than in *Deinodon*, not so large as in *Struthiomimus*. Lateral temporal fenestra of good size, much as in *Deinodon*, not reduced as in *Struthiomimus*. Preorbital fenestræ at present known only inferiorly, but evidently large. Frontals comparatively long and wide, the nasals overlapping them considerably, especially at the median line. The prefrontal and postfrontal sutures continuous, not separated by an orbital notch. Maxillo-premaxillary suture nearly vertical, the premaxilla large.

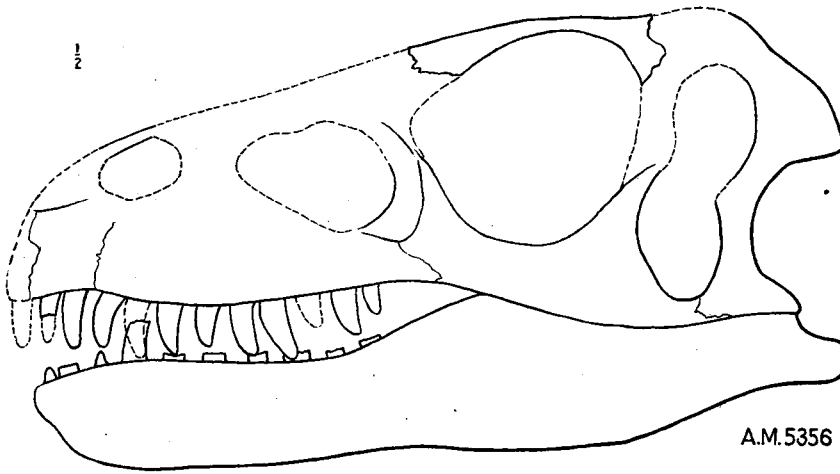

Fig. 1. Type skull of *Dromæosaurus albertensis*, one-half natural size.

The top of the skull is fragmentary and the specimen is at present only partly prepared, so that the above diagnosis will be completed and perhaps modified in some details in a later article. The skull is most like that of *Deinodon* in general proportions, but from a third to a fourth as large lineally, and but little larger than that of *Struthiomimus altus*. It differs from *Deinodon* in the reduced number of teeth, the large premaxillary teeth and the unsymmetric form of the maxillary teeth as well as in the light skull construction, large fenestræ and numerous details that might be largely associated with its small size.

The foot bones are very different from those of either *Deinodon* or *Struthiomimus*, but so fragmentary that they are not positively identifiable, and no generic characters can be based upon them.

The distal half of a metapodial, slightly larger than the mc. II of *Struthiomimus* and only a little smaller than mc. II of *Deinodon* (despite the enormous difference in size of the skeleton) has a deeply grooved ginglymoid distal facet, as in *Deinodon*, but shows a very distinct lateral appression surface. In *Struthiomimus* there is an appression surface on mc. II, but the distal end of the bone is wholly different with a con-

vex condylar facet; it also is of about the same size. Another much smaller metapodial has a less distinctly grooved distal facet and more irregular shaft that may be incomplete proximally. Of the phalanges there are three that fit so closely that they appear to belong with the metapodial first mentioned, but if so it must be the fourth digit, not the second, and may belong to the pes instead of the manus. A fourth phalanx is of similar type but distinct in details from any of the first three. A fifth is a proximal phalanx of size more suited to the smaller metapodial above mentioned, but does not fit it; it is rather short with concave basined head and laterally compressed distal end, apparently a phalanx of the first digit. A sixth phalanx is much larger than the others but only the distal end is preserved, its facet deeply grooved and very similar to the distal facet of the metapodial first noted. Possibly, but not probably, this is a median metapodial.

The comparison of these bones with the complete manus and pes of *Struthiomimus* and of *Deinodon* shows clearly that *Dromæosaurus* differs greatly in the construction of manus or pes, or both, from either of these genera and suggests a less degree of specialization and reduction of the digits in manus or pes.

Although provisionally referred to the family Deinodontidæ, the differences in the skull, number of teeth, and form of premaxillary teeth, together with the apparent diversity in construction of the foot bones, warrant placing *Dromæosaurus* in a distinct subfamily Dromæosaurinæ.