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REMARKS ON THE REPTILES GENERALLY CALLED DINOSAURIA.

BY G. BAUR.

THE name Dinosauria was proposed by Prof. Richard Owen (1), in a paper on "British Fossil Reptiles," read before the ninth meeting of the British Association, at Birmingham in 1839. In this order were placed the genera Megalosaurus, Hylæosaurus, and Iguanodon. Already in 1830, however, Hermann v. Meyer (2) had placed Megalosaurus and Iguanodon in a peculiar group of the fossil saurians, with "Extremitaeten wie bei den schweren Landsäugethieren." Kaup (3) follows H. v. Meyer, and calls the order containing Iguanodon and Megalosaurus: *Rieseneidechsen, Megalosaurier.*

Owen gave the following characters for the group he had called Dinosauria (*l. c.*, p. 102, 103):

DINOSAURIANS.

"This group, which includes at least three well-established genera of saurians, is characterized by a large sacrum composed of five anchylosed vertebræ of unusual construction, by the height and breadth and outward sculpturing of the neural arch of the dorsal vertebræ, by the two-fold articulation of the ribs to the vertebræ, viz., at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only, by broad and sometimes complicated coracoids and long and slender clavicles, whereby crocodilian characters of the vertebral column are combined with a lacertilian type of the pectoral arch; the dental organs also exhibit the same transitional or annectent characters in a greater or less degree. The bones of the extremities are of large proportional size, for saurians; they are provided with large medullary cavities and with well-developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble

those of the heavy pachydermal mammals, and attest, with the hollow, long bones, the terrestrial habits of the species. The combination of such characters, some as the sacral ones, altogether peculiar among reptiles, others borrowed, as it were, from groups now distinct from each other, and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe or suborder of saurian reptiles, for which I would propose the name of Dinosauria " (p. 103).

A few years later, in 1843, Fitzinger (4) placed Megalosaurus in the family " Megalosauri," among the Loricata; Iguandon we find under the family name " Therosauri," among the order Sauri.

In 1845 H. v. Meyer (5) introduced the name Pachypodes for the group he had established in 1830, including Iguanodon, Hylæosaurus, Megalosaurus, Plateosaurus.

Paul Gervais (6) established the families Megalosauridæ and Iguanodontidæ in 1853, without giving definition.

In 1866 Owen (7) characterized the Dinosauria thus:

" Cervical and anterior dorsal vertebræ with par- and diapophyses, articulating with bifurcated ribs; a few anterior vertebræ, more or less convex in front and cupped behind, the rest with flat or slightly concave articular ends; dorsal vertebræ with a neural platform; sacral vertebræ exceeding two in number; body supported on four strong ambulatory unguiculate limbs. Skin in some armed by bony scutes. Teeth confined to upper and lower jaws, implanted in sockets." He names the genera: Iguanodon, Scelidosaurus, Megalosaurus.

In the same year Haeckel (8) and Cope gave the first classification of the Dinosauria.

Haeckel considers the Dinosauria a subclass, which he divides in two orders:

" Erste Ordnung der Dinosaurier: Harpagosauria H.; Carnivore Lindwürmer. Zweite Ordnung der Dinosaurier: Therosauria H.; Herbivore Lindwürmer."

Haeckel uses the same name as Fitzinger for the herbivorous forms represented by Iguanodon.

The Harpagosauria are represented by Megalosaurus, Hylæosaurus, Telorosaurus.

Cope's first note on the classification of the Dinosaurs was published in the Proc. Acad. Nat. Sci., Phila., 1866, p. 317. He distinguishes Orthopoda with the genera Scelidosaurus Ow., Hylæosaurus Mont., Iguanodon Mont., Hadrosaurus Leidy; and Goniopoda with the genera Lælaps Cope and Megalosaurus Buckl.

In 1870 Cope (9) characterized these in the following way:

ORTHOPODA.

"Cope, Proc. Ac. Nat. Sci., Phila., 1866, 317. Therosauria Haeckel, 1866. Proximal tarsal bones distinct from each other and from the tibia, articulating with a tibia and with a terminal face of a well-developed fibula. The ilium with a massive, narrowed, anterior prolongation. Hadrosauridæ, Iguanodontidæ, Scelidosauridæ."

GONIOPODA COPE.

"Proc. Ac. Nat. Sci., Phila., 1866, 317. Harpagosauria Haeckel, 1866. Proximal tarsal bones distinct from tibia; the latter closely embraced by the much-enlarged astragalus, on its inferior and anterior faces, forming an immovable articulation. Astragalus with an extensive anterior articular condyle below, above in contact with the fibula, which is much reduced, especially distally. Anterior part of the ilium dilated and plate-like. Lælaps, Poecilopleuron, Megalosaurus, Cœlosaurus, and perhaps Bathygnathus and Aublysodon."

In the same paper a third group, SYMPHYPODA, is established, with the genera Compsognathus and Ornithotarsus and the following characters:

"First series of tarsal bones confluent with each other and with the tibia. Fibula distally much reduced. Anterior part of ilium dilated, plate-like."

Later it was found that Ornithotarsus belonged to the Orthopoda, Compsognathus to the Gonipoda.

Huxley (10) gave the first characteristic of the Dinosauria in 1869. "The bony exoskeleton is sometimes more highly

developed than in the Crocodilia, and sometimes absent. The centra of the posterior dorsal vertebræ are flat or slightly concave at each end, and they have crocodilian transverse processes and ribs. The centra of the anterior dorsal and of the cervical vertebræ are sometimes concave behind and convex in front (opisthocœlous). There are four or more vertebræ in the sacrum. The pelvis and bones of the hind limb are in many respects very like those of birds. No clavicles have been observed, and the fore limb is sometimes very small in proportion to the hind limb."

One year later Prof. Cope (11) gave the following characters: "Limbs ambulatory or prehensile. Ilium horizontal, supporting a long sacrum of five or six vertebræ, the anterior derived from the lumbar series. The acetabulum thrown forwards, and not complete, but perforate. Ischium long, longitudinal, posterior, supporting the parts, in front of a process. Ribs free, double-headed. Neural arches united by suture; chevron bones present."

The next paper is Prof. Huxley's (12) well-known memoir on the classification of the Dinosauria. The order Ornithoscelida is created, with two suborders:

"I. Dinosauria, with the cervical vertebræ relatively short, and the femur as long as or longer than the tibia.

II. The Compsognatha, with the cervical vertebræ relatively long, and the femur shorter than the tibia."

The Dinosaurs are now characterized fully:

"1. The dorsal vertebræ have amphicœlous or opisthocœlous centra They are provided with capitular and tubercular transverse processes, the latter being much the longer.

2. The number of the vertebræ which enter into the sacrum does not fall below two, and may be as many as six.

3. The chevron bones are attached intervertebrally, and their rami are united at their vertebral ends by a bar of bone.

4. The anterior vertebral ribs have distant capitula and tubercula.

5. The skull is modeled upon the lacertilian, not on the crocodilian, type. There is a bony sclerotic ring.

6. The teeth are not anchylosed to the jaws, and may be lodged in distinct sockets. They appear to be present only in the premaxillæ, maxillæ, and dentary portions of the mandible.

7. The scapula is vertically elongated; the coronoid is short, and has a rounded and undivided margin. There is no clavicle.

8. The crest of the ilium is prolonged both in front of and behind the acetabulum, and the part which roofs over the latter cavity forms a wide arch, the inner wall of the acetabulum having been formed by membrane, as in birds.

9. The ischium and pubis are much elongated.

10. The femur has a strong inner trochanter; and there is a crest on the ventral face of the outer condyle, which passes between the tibia and the fibula, as in birds.

11. The tibia is shorter than the femur. The proximal end is produced anteriorly into a strong crest, which is bent outwardly, or towards the fibular side.

12. The astragalus is like that of a bird; and the digits of the pes are terminated by strong and curved ungual phalanges."

The Dinosaurs are divided by Huxley into three families:

I. Megalosauridæ; Teratosaurus, Palæosaurus, Megalosaurus, Poikilopleuron, Lælaps, and probably Euskelosaurus.

II. Scelidosauridæ; Scelidosaurus, Thecodontosaurus, Hylæosaurus, Polacanthus (?), Acanthopholis.

III. Iguanodontidæ; Cetiosaurus, Iguanodon, Hypsilophodon, Hadrosaurus, and probably Stenopelyx.

With 1877 begin the publications of Prof. O. C. Marsh, based on the extensive collections brought together by his collectors.

In 1877 a new order of reptiles is named Stegosauria, but no characters are given (13).

The year following the order Sauropoda of the Dinosauria is established (14), to contain the very large reptiles, named by Marsh Atlantosaurus, Apatosaurus, Morosaurus, and Diplodocus, and by Cope Camarasaurus, Amphicœlias, etc. The characters of this order are:

SAUROPODA.

"1. The fore and hind limbs are nearly equal in size.

2. The carpal and tarsal bones are distinct.

3. The feet are plantigrade, with five toes on each foot.

4. The precaudal vertebræ contain large cavities, apparently pneumatic.

5. The neural arches are united to the centra by suture.

6. The sacral vertebræ do not exceed four, and each supports its transverse process.

7. The chevrons have articular extremities.

8. The pubes unite in front by ventral symphysis.

9. The third trochanter is rudimentary or wanting.

10. The limb bones are without medullary cavities."

Cetiosaurus, a member of this group, had always been considered as one of the Crocodilia, and Owen (15) had placed it in a special group, Opisthocœlia.

In this Owen was followed by Haeckel, but not by Huxley, who placed Cetiosaurus among the Iguanodontidæ. Seeley introduced the name Cetiosauria in 1874.

Another new order of reptiles was created by Marsh (16), under the name Cœluria, without characters, in 1881.

In the same year the first classification of the Dinosauria is given by Marsh (17).

The Dinosaurs are considered an order, and divided in five suborders: Sauropoda, Stegosauria, Ornithopoda, Theropoda, Hallopoda, Cœluria. The diagnoses are thus given:

Order Dinosauria Owen.

"1. Suborder Sauropoda (lizard foot). Herbivorous. Feet plantigrade, ungulate; five digits in manus and pes. Pubes united in front by cartilage. No postpubis. Precaudal vertebræ hollow; limb bones solid. Family, Atlantosauridæ; genera, Atlantosaurus, Apatosaurus, Brontosaurus, Diplodocus, and Morosaurus.

2. Suborder Stegosauria (plated lizard). Herbivorous. Feet plantigrade, ungulate; five digits in manus and pes. Pubes free in front. Postpubis present. Vertebræ and limb bones solid. Family, Stegosauridæ; genus, Stegosaurus.

3. Suborder Ornithopoda (bird foot). Herbivorous. Feet digitigrade; four functional digits in manus and three in pes.

Pubes free in front. Post pubis present. Vertebræ solid; limb bones hollow. Family, Camptonotidæ; genera, Camptonotus, Diracodon, Laosaurus, and Nanosaurus.

4. Suborder Theropoda (beast foot). Carnivorous. Feet digitigrade; digits with prehensile claws. Pubes coösified in front. Post-pubis present. Vertebræ more or less cavernous; limb bones hollow. Family, Allosauridæ; genera, Allosaurus, Creosaurus, and Labrosaurus.

5. Suborder Hallopoda (leaping foot). Carnivorous (?). Feet digitigrade, unguiculate; three digits in pes. Metatarsals much elongated; calcaneum much produced backward. Two vertebræ in sacrum. Limb bones hollow. Family, Hallopodidæ; genus, Hallopus.

DINOSAURIA (?)

6. Suborder Cœluria (hollow tail). Carnivorous (?). Family, Cœluridæ; genus, Cœlurus."

The year following, 1882, the Dinosauria are placed in a subclass, with five orders (18).

a. Sauropoda. *b*. Stegosauria. 3. Ornithopoda. 4. Theropoda. 1. Suborder Cœluria. 2. Suborder Compsognatha. 5. Hallopoda.

The subclass Dinosauria is characterized in the following words:

" Premaxillary bones separate; upper and lower temporal arches; rami of lower jaw united in front by cartilage only; no teeth on palate. Neural arches of vertebræ united to centra by suture; cervical vertebræ numerous; sacral vertebræ coössified. Cervical ribs united to the vertebræ by suture or anchylosis; thoracic ribs double-headed. Pelvic bones separate from each other, and from sacrum; ilium prolonged in front of acetabulum; acetabulum formed in part by pubis; ischia meet distally on median line. Fore and hind limbs present, the latter ambulatory and larger than those in front; head of femur at right angles to condyles; tlbia with procnemial crest; fibula complete. First row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint."

After this Cope (19) established the following system, considering the Dinosaurs an order, with four suborders.

"Feet ungulate; pubis projecting and connected in front; no postpubis. *Opisthocœlia.*
Feet ungulate; pubes projecting free in front; postpubis present. *Orthopoda.*
Feet unguiculate; pubes projecting downwards and coössified distally; calcaneum not produced. *Goniopoda.*
Feet unguiculate; calcaneum much produced backwards; (?) pelvis. *Hallopoda.*"

In 1884 Marsh (20) again published another classification. He divided the sub-class Dinosauria into four orders and three suborders:

1. Order Sauropoda.
2. " Stegosauria.
3. " Ornithopoda.
4. " Theropoda.
   Suborder Cœluria.
   " Compsognatha.
   " Ceratosauria.

The Hallopoda are now considered an order of reptiles, not placed within the Dinosaurs.

In 1885 Cope (21) placed the Crocodilia among the Dinosauria, and gave the following character: "Os quadratum immovably articulated, capitular and tubercular rib articulations distinct. Ischium and pubis distinct, the latter directed forwards, backwards, or downwards; two posterior cranial arches; limbs ambulatory; no procoracoid."

In 1887 (22) Baur divided the Dinosauria in three groups:

"A. Carnivorous Dinosaurs, Harpagosauria Haeckel, 1866.
   I. Goniopoda Cope, 1886 (Theropoda Marsh, 1881).
B. Herbivorous Dinosaurs, Therosauria Haeckel, 1866.
   II. Orthopoda Cope, 1866.
      1. Ornithopoda Marsh, 1881.
      2. Stegosauria Marsh, 1877.
C. Crocodilian-like Dinosaurs, Sauropoda Marsh, 1878.
   III. Opisthocœlia Owen, 1859."

In the same year Prof. Seeley (23) gave a new classification.

He reached the result "that the Dinosauria has no existence as a natural group of animals, but includes two distinct types of animal structure." These two orders are called Ornithischia and Saurischia.

ORNITHISCHIA.

"In this order the ventral border of the pubic bone is divided so that one limb is directed backward parallel to the ischium, as among birds, and the other limb is directed forward. Neither of these limbs of the pubis appears to form a median symphysis. The ilium is prolonged in front of the acetabulum as a more or less slender processor bar. The vertebræ are solid, and the skeleton is not pneumatic. The basicranial structure is distinctive differing from that of crocodiles and lizards. The body and limbs are frequently covered with scutes, which many form a complete shield or be reduced so as to be unrecognizable. The digits vary from three to five."

SAURISCHIA.

"In this order the pubis is directed forward from its symphysis with the ischium, and no posterior limb of the bone is developed. Both pubis and ischium appear to meet by a median symphysis, so that the arrangement and relation of the bones are lacertilian. The anterior prolongation of the ilium has a vertical expansion. The vertebræ are more or less pneumatic or cavernous, and in the dorsal region the neural arch is commonly elevated. The basicranial structure is sub-lacertilian. No armor has been found. The digits vary in number from three to five."

In 1889 Marsh (24) admits four orders of Dinosauria: Sauropoda, Stegosauria, Ornithopoda, Theropoda; Ceratosaurus, Hallopus, and Compsognathus being placed among the Theropoda.

Cope (25) admits, partially at least, Seeley's classification, but he keeps the order Dinosauria, which he divides in two suborders: Saurischia and Orthopoda; the first with the inferior pelvic elements directed downwards, the second with the pelvic elements directed backwards.

Lydekker (26) divides the order Dinosauria in three suborders: Sauropoda, Theropoda, Ornithopoda. In the Ornithopoda he includes the Stegosauria of Marsh.

In 1889 he keeps this arrangement and divides the suborders in the following families (27):

I. Ornithopoda.—Trachodontidæ, Iguanodontidæ, Scelidosauridæ, Stegosauridæ, Ceratopsidæ.

II. Theropoda.—Anchisauridæ, Megalosauridæ, Compsognathidæ, Cœluridæ.

III. Sauropoda.—Atlantosauridæ, Diplodocidae, Cetiosauridæ.

In 1890 Prof. Marsh (28) separated the Hallopoda from the Dinosauria with query, and placed them in a special order; at the same time he gave the family Ceratopsidæ, which he had established in December, 1888 (*Am. Journ. Sci.*), the rank of a suborder, with the name Ceratopsia.

After this Baur (29) expressed the opinion that Hallopus is nearly related to Compsognathus, and that it is unnatural to place the Ceratopsidæ in a special suborder.

In the latest paper on the subject Prof. Marsh (30) has given up the suborder Ceratopsia, considering the Ceratopsidæ a family only.

Prof. Zittel (31) retains the order Dinosauria, which he divides in this way:

I. Unterordnung Sauropoda. Families: 1. Cetiosauridæ. 2. Atlantosauridæ. 3. Morosauridæ. 4. Diplodocidæ.

II. Unterordnung Theropoda. Families: 1. Zanclodontidæ. 2. Megalosauridæ. 3. Ceratosauridæ. 4. Anchisauridæ. 5. Cœluridæ. 6. Compsognathidæ. 7. Hallopidæ.

III. Unterordnung Orthopoda. A. Stegosauria. Families: 1. Scelidosauridæ. 2. Stegosauridæ. B. Ceratopsia. C. Ornithopoda. Families: 1. Camptosauridæ. 2. Iguanodontidæ. 3. Hadrosauridæ. 4. Nanosauridæ. 5. Ornithominidæ.

After this review of the general classification of Dinosaurs we see that there are quite a number of different ideas. Leaving the older views aside, we have to-day the following principal opinions, taking the latest views of the different authors.

A. *The Dinosauria are a Natural Group.*—1. The Dinosauria form a subclass of reptiles, containing four orders: 1. Sauropoda. 2. Stegosauria. 3. Ornithopoda. 4. Theropoda (Marsh).

2. The Dinosauria form an order of reptiles, containing three suborders: Sauropoda, Ornithopoda, Theropoda (Lydekker); Sauropoda, Orthopoda, Theropoda (Zittel).

3. The Dinosauria form an order of reptiles, containing two suborders: Saurischia, Orthopoda (Cope).

B. *The Dinosauria are not a Natural Group.*—The reptiles generally called Dinosauria belong to two distinct orders: Ornithischia and Saurischia (Seeley).

The first question to decide is, Do the Dinosauria represent a natural group or not? To examine this we will proceed to study a member of each of the three groups, Sauropoda, Orthopoda, and Theropoda, and compare these members among themselves. Of the Orthopoda especially we will take as a type Iguanodon, the structure of which is best known through the different publications of Dollo in the Bull. Musée Royal d'His. Nat. de Belgique; of the Sauropoda we will take Diplodocus, described by Marsh; and of the Theropoda, Ceratosaurus, also made known by Marsh. We begin with the skull, then treat the vertebræ, the shoulder girdle, the pelvis, the fore and hind limbs, the abdominal ossicles, and the dermal ossification so far as necessary.

I. THE SKULL.

Iguanodon.—All that I have to say about Iguanodon is based on the careful descriptions of Dollo (32).

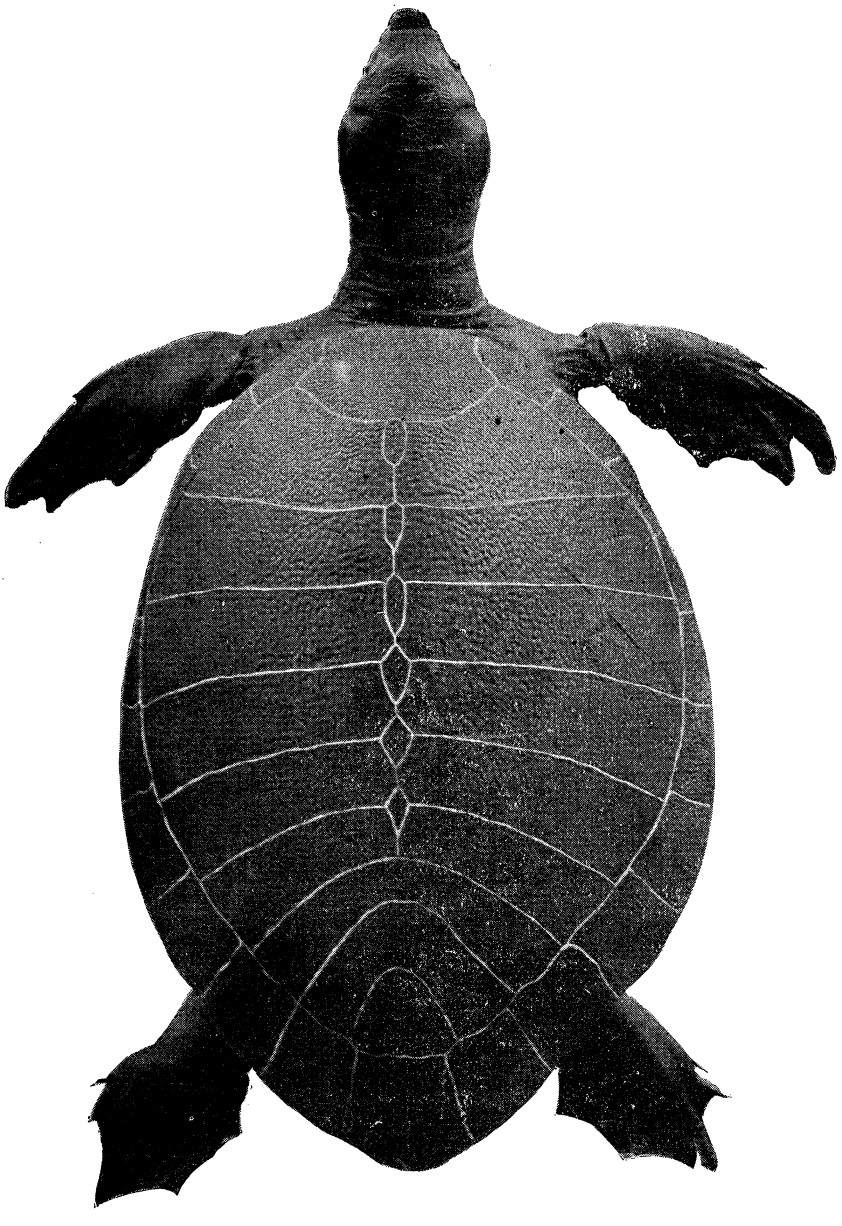
1. The brain-case is completely ossified; a very strong alisphenoid being present.

2. The premaxillaries are separate, and there is a strong process extending between the nasals and mandibles, excluding the maxillaries from the nasal opening.

3. No epipterygoid (columella).

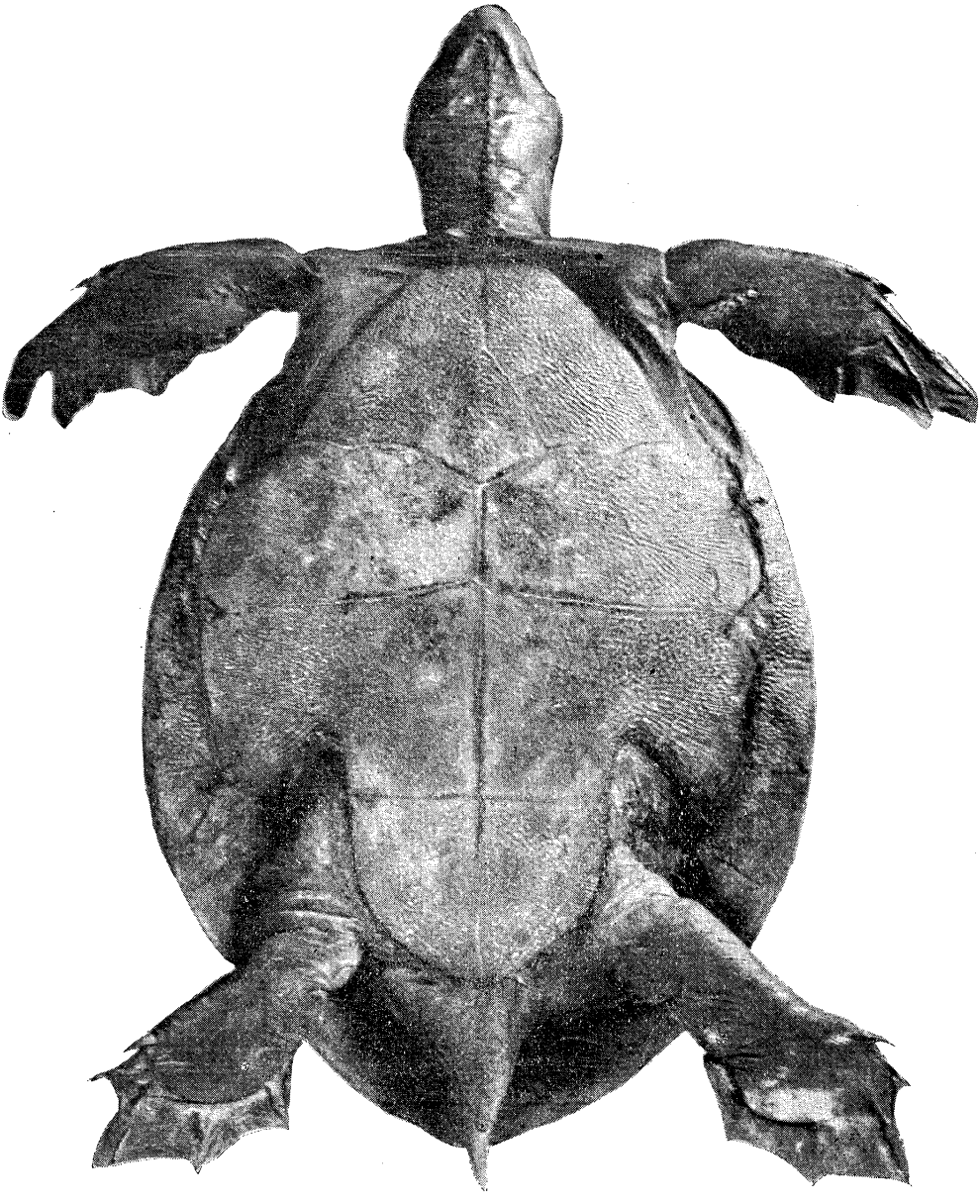
4. The jugals are fixed to a special process of the maxillaries; they are not placed in the same level with the alveolar border, but a considerable distance outside of it. They do not reach the end of the dental series. They are in connection with the lachrymals, postfrontals, quadratojugals, and maxillaries. They bound the orbits inferiorly, and also somewhat posteriorly.

PLATE XIV.



Carettochelys insculpta.

PLATE XV.



Carettochelys insculpta.

5. The quadratojugals are placed between quadrate and jugal, but do not touch the squamosal.

6. The squamosals do not send down a process to join the quadratojugal.

7. The quadrate is very elongate, with its lower end directed forwards; there is a well-developed pterygoid process.

8. The mandible has a distinct predentary line.

9. The dentary has a greatly developed coronoid process.

10. The external nasal openings are limited by the premaxillaries and nasals.

11. The prelachrymal fossæ are small, and limited by the maxillaries, prefrontals, and lachrymals.

12. The orbits are limited by the supraorbitals, lachrymals, jugals, and post-fronto-orbitals.

Diplodocus.—These notes on Diplodocus are based on the figures of Prof. Marsh, which, however, are not quite correct, as I found from the study of the original specimens.

1. The brain-case is completely ossified; a very strong alisphenoid being present.

2. The premaxillaries are separate, and there is no process extending between the nasals and maxillaries, excluding the maxillaries from the nasal opening.

3. No epipterygoid (columella).

4. The jugals are placed in the same level with the alveolar border of the maxillaries. They do not reach the end of the dental series. They are in connection with the lachrymals, postorbitals, quadratojugals, and maxillaries. They bound the orbits only pre-inferiorly.

5. The quadratojugals are placed between the quadrate and maxillary, but do not touch the squamosal.

6. The squamosals do not send down a process to join the quadratojugals.

7. The quadrate is elongate with its lower end strongly directed forward. There is a very large pterygoid process.

8. The mandible has no predentary bone.

9. The dentary is without coronoid process.

10. The external nasal openings are limited by the premaxillaries, maxillaries, and nasals.

11. The prelachrymal fossæ are large, limited by the maxillaries, prefrontals, lachrymojugals. (The suture between jugals and lachrymals seems to be very indistinct.)

12. The orbits are limited by the post-fronto-orbitals, and lachrymojugals.

Ceratosaurus.—Mostly after Marsh. 1. The brain-case is not ossified in front; there are no strongly ossified alisphenoids; this region like Sphenodon.

2. The premaxillaries are separate; there is no process extending between the nasals and maxillaries, excluding the maxillaries from the nasal opening.

3. An epipterygoid (columella).

4. The jugals are placed in the same level with the alveolar border of the maxillaries, and reach the end of the dental series. They are in connection with the lachrymals, postorbitals, quadratojugals, and maxillary.

5. The quadratojugal is placed between quadrate and jugal, and seems to touch the squamosal.

6. The squamosal sends down a small process to join the quadratojugal.

7. The quadrate is very much like that of Sphenodon, with a foramen between quadratojugal and quadrate, and directed backwards with its distal end. There is a very large pterygoid process.

8. Mandible without predentary bone.

9. Dentary without coronoid process.

10. The external nasal openings are limited by the premaxillaries, nasals, and maxillaries.

11. The prelachrymal fossæ are large, limited by the prefrontals, lachrymals, jugals, and maxillaries.

12. The orbits are limited by the prefrontals, frontals, post-fronto-orbitals, jugals, and lachrymals.

By comparing these three forms it is evident that Iguanodon stands quite isolated. It shows the peculiar lower jaw, the peculiar

nasal openings from which the maxillaries are excluded,[1] and the peculiar maxillary with the free posterior dentary end.

From the study of the skulls alone it is evident that Iguanodon has to be separated entirely from Diplodocus and Ceratosaurus; that there is no affinity whatever among these animals, which could permit us to place them in a common group may it be called a subclass or an order of reptiles.

But I have to say exactly the same in regard to Diplodocus and Ceratosaurus. Diplodocus is of a crocodilian pattern, showing a well-developed alisphenoid; Ceratosaurus, however, is typically Rhynchocephalian or Proganosaurian in nearly every detail, and it is certainly very much more related to these groups than to any other group of the so-called Dinosauria. The study of the skull alone would be sufficient to show that the Dinosauria is an absolutely unnatural group without any right of existence; it shows that the three members, Iguanodon, Diplodocus, and Ceratosaurus belong to three distinct groups of Monocondylia, with very little relation to each other.

II. THE VERTEBRÆ.

The vertebræ are of the character of the Archosauria, the dorsals having well-developed transverse processes. As is well known from the study of the Testudinata and Crocodilia, the character of the articular faces of the centra of the vertebræ is of very little value in tracing the phylogenetic relation of groups. The sacrum, however, shows peculiarities.

Iguanodon.—In Iguanodon the sacral ribs are placed more or less between the centra of the sacral vertebræ. They are united to distinct diapophyses of the neural arches and to the centrum; the diapophysis may extend in some forms (Agathaumas) as far as the end of the sacral rib, but it is never separated from it. In other words, in Iguanodon the ilium is separated by sacral ribs, which are placed between the centra and to which diapophyses of the neural arches are suturally united or coössified.

[1] This condition resembles very much that seen in mammals, in which we also have a process of the premaxillary extending between nasal and maxillary. In birds the maxillary is excluded from the nasal opening by the descending branches of the nasal. A somewhat intermediate condition is seen in Aëtosaurus.

Diplodocus.—In Diplodocus and its allies the sacral ribs are not intervertebral, but are connected with the centra of the vertebræ only, without diapophyses.

Ceratosaurus.—In Ceratosaurus and its allies the sacral ribs are intervertebral, but entirely free from the well-developed diapophyses, which also support the ilium. The diagrammatic figures show these relations. We see also that the structure of the sacrum shows greater differences than we find in a natural group, and also shows that the Dinosauria must be given up.

III. THE SHOULDER GIRDLE.

In the shoulder girdle we find, as in all Archosauria, a simple coracoid and an elongate scapula. So far no clavicles have been found, and I think that these elements are absent in Iguanodon and Diplodocus and the allied forms, but I should not be surprised at all if further discoveries would demonstrate the presence of clavicle and interclavicle in the megalosauroid forms.

IV. THE PELVIS.

Iguanodon.—The pubis of Iguanodon and its allies at once distinguishes it from all the other groups. As is well known and now shown without doubt, the ectopubis or pectineal process in this form is exceedingly developed; the entopubis or true pubis being directed backwards This character alone is sufficient to separate Iguanodon far from Diplodocus and Ceratosaurus. In the highest specialized members of the Iguanodon group—Agathaumas (Triceratops), for instance—the ectopubis is enormously developed, the entopubis being quite rudimentary.

Diplodocus.—Here we have the pubis directed forwards, and pierced by the obturator foramen, all the bones of the pelvis being very massive.

Ceratosaurus.—Also in this form the pubes are directed forwards, but are closely united at the distal two-thirds, appearing like a chevron bone when seen from front; also the ischia are united at the distal end; the elements of the pelvis being slender.

It is evident that Diplodocus and Ceratosaurus resemble each other very much more in the structure of the pelvis than they do

in comparison with Iguanodon. The pelvis of these two forms can be reduced to the type seen in the Rhynchocephalia and Squamata.

V. THE FORE AND HIND LIMBS.

The structure of the limbs is of very great taxonomic value in a definite animal group of forms; but if we would take the limbs alone to establish a system we would be led to the most absurd results. The order Enaliosauria was established for the Ichthyosaurs, and Plesiosaurs which are provided with paddles. But this is only a parallelism in structure. The Plesiosauria have no relations whatever to the Ichthyosauria. The same we may say in regard to the Dinosauria. The Iguanodon-like forms resemble very much the Megalosaurus-like forms; but there cannot be the slightest doubt that this resemblance does not mean affinity, but parallelism.

VI. ABDOMINAL OSSICLES.

So-called abdominal ribs were present in the megalosauroid forms, as shown by Deslongchamps. They have not been discovered yet in Iguanodon and Diplodocus, and it is impossible to determine with our present knowledge whether they were present or not.

VII. DERMAL OSSIFICATIONS.

Dermal ossifications are known in the Iguanodon-like forms, especially in the highly developed Stegosauridæ and Agathaumidæ; they seem to be absent in the Diplodocus and Ceratosaurus forms. I do not consider such ossifications of great taxonomic value, especially not for ordinal characters.

If we now recapitulate, we have found that the structure of the skull and sacrum of Iguanodon, Diplodocus, Ceratosaurus, make it sure that these three animals are in no near relation to each other; that they doubtless are the representatives of three different groups; that the Dinosauria have to be given up. The question now comes up, What names shall we apply to the three groups of archosaurian reptiles represented by Iguanodon, Diplodocus, and Ceratosaurus?

Iguanodon belongs to the group which has been called Therosauri by Fitzinger, 1843; Therosauria by Haeckel, 1866; Orthopoda by Cope, 1866; Ornithopoda and Stegosauria by Marsh, 1881; Ornithischia by Seeley, 1887. Of all these names that of Therosauri or Therosauria has the priority. But I do not believe that this name will be favored. I think it best to introduce a new significant name for this group of archosaurian reptiles: *Iguanodontia*,—like Crocodilia, Plesiosauria, Ichthyosauria, Aëthosauria, etc., the most typical representative of this group being Iguanodon. To this group belong the families, Iguanodontidæ, Hypsilophodontidæ, Hadrosauridæ, Ornithomimidæ (?), Scelidosauridæ, Stegosauridæ, Agathaumidæ.[2]

Diplodocus belongs to the group which has been called Opisthocœlia by Owen, 1859; Cetiosauria by Seeley, 1874; Sauropoda by Marsh, 1878. I think it best to use the name *Cetiosauria* introduced by Seeley, Cetiosaurus being the oldest member of the group, and doubtless synonymous with one and probably more of the American genera. Of this group there is evidence so far of only one family, the Cetiosauridæ.

Ceratosaurus is a member of the group which has been called Megalosauri by Fitzinger, 1843; Harpagosauria by Haeckel, 1866; Goniopoda by Cope, 1866; Theropoda by Marsh, 1881; I propose to use the name *Megalosauria* for this group. It is the oldest name used, and Megalosaurus is the oldest genus known, and there is no doubt that one or more of the American generic names will prove to be synonyms of it.

In this group the following families can be distinguished: Zanclodontidæ, Anchisauridæ, Megalosauridæ, Compsognathidæ, Cœluridæ.[3]

As the result of this paper I may state this:

1. The group generally called Dinosauria is an unnatural one, which is composed of three special groups of archosaurian rep-

[2] Ceratops Marsh is the same as Monoclonius Cope, as I know from actual study of the types. That Agathaumas Cope is the same as Triceratops Marsh will be admitted by everybody who will compare the original plates of the sacrum, dorsal vertebræ, and the ilium of Agathaumas, by Cope, with those of Triceratops, given by Marsh.

[3] I think that Macellognathus Marsh, which has nothing whatever to do with the Testudinata, belongs to this family and to Cœlurus.

tiles, without any close relation between each other. The Dinosauria do not exist.

2. The so-called Dinosauria contain three groups of reptiles, which ought to be called Iguanodontia, Megalosauria, and Cetiosauria.

The distinctive character of these three groups are:

IGUANODONTIA.

Brain-case completely ossified; a well-developed alisphenoid; no epipterygoid (columella); premaxillaries with a posterior outer process extending between nasals and maxillaries, excluding maxillaries from nasal openings; jugals fixed to a special process of the maxillary outside the alveolar border; posterior alveolar end of maxillaries free; not connected with jugals or quadratojugals; quadrate directed forward; mandible with a distinct predentary bone; dentary with greatly developed coronoid process; sacral vertebræ with ribs and diapophyses united, intervertebral; pubis consisting of two branches; the anterior one ectopubis (pectineal process, prepubis) greatly developed: the entopubis directed backwards, well developed or rudimentary; ilium very much extended in front and also behind.

CETIOSAURIA.

Brain-case completely ossified; a well-developed alisphenoid; no epipterygoid (columella); premaxillaries not excluding maxillaries from nasal opening; jugal and quadratojugal forming a continuation of the posterior border of the maxillary in the same plane; quadratojugal in connection with maxillary; quadrate directed forwards; mandible without predentary bone; dentary without coronoid process; sacral vertebræ with ribs only vertebral; pubis consisting of one branch, the entopubis only, directed forwards.

MEGALOSAURIA.

Brain-case not ossified in front; no ossified alisphenoid; an epterygoid (columella); premaxillaries not excluding maxillaries from nasal opening; jugal connected with alveolar end of maxillary, on the same plane; quadratojugal free from maxillary; quad-

rate directed backwards; mandible without predentary bone; dentary without coronoid process; sacral vertebræ with ribs intervertebral; and diapophyses without connections with ribs; pubes directed forwards, and strongly united at the ends.

The Iguanodontia appear in the Lias with all characters (Scelidosaurus), and form an absolutely isolated group so far. The nearest relations seems to be with birds rather than with any other groups of the Monocondylia. Whether the peculiar condition of the premaxillaries and the relations of the jugal to the maxillary, which remind us of the arrangement in mammals and some Theromora, indicates affinity to the ancestral forms of these groups, I am unable to say; but the fact that in mammals the pubis is also turned back has to be noticed.

The Iguanodontia reach to the Upper Cretaceous, and show in Agathaumas and Diclonius their highest specialization.

The Cetiosauria are confined to the Jurassic, Wealden, and Cretaceous (Cambridge Greensand).[4] They seem to have their nearest relatives in the Belodontidæ. The Crocodilia, with their peculiar pelvic arch, seem to be also related to this group.

The Megalosauria extend from the Triassic to the Cretaceous. The skull is of the pattern of Paleohatteria of the Proganosauria and the Rhynchocephalia, and it seems very probable to-day that the Megalosauria have developed from the Rhynchocephalia. Protorosaurus seems to be in this line.

The earliest reptiles doubtless go back to the Carboniferous, from which formation we do not know a single reptile so far. This is made probable by the existence in the Permian and Lower Triassic of different groups of Reptilia. It is very likely that birds began to be branched off already in the Lower Triassic, probably from a group which gave also origin to the Iguanodontia; but to decide this question is not possible to-day. I still believe with Hitchcock that a great number of the tracks in the Connecticut Triassic sandstone are the tracks of true birds, not of any of the Megalosauria known to-day. All Megalosauria known have a long tail, and we ought

[4] The metatarsals figured by Seeley of a Dinosaur from the Cretaceous Greensand cannot be distinguished from those of Morosaurus.

to expect to find impressions of a tail, with the impressions produced by the hind limbs, but this we do not. The impressions, therefore, seem to be produced by an animal having a short tail. Some characters of birds remind us of the Megalosauria; but the fact remains that we know hardly anything about the actual ancestors of this branch of the Monocondylia. The birds have a well-ossified alisphenoid, no epipterygoid, and there seems to be little doubt that the avian ancestors of the birds of to-day had already this character; but the ancestors of these must have had the brain-case open in front, no ossified alisphenoids, but an epipterygoid; and here, again, we reach a form like the Proganosauria and Rhynchocephalia.

Clark University, Worcester, Mass., Feb. 11th, 1891.

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