the Loess presents traces everywhere of a great diluvial movement. I cannot follow him in attributing it to the Glacial period, and to the bursting of a huge barrier of ice letting loose the waters of a great inland lake. All this seems to me to be at issue with the evidence, but I must claim what he says as to a great debacle, as, in fact, a proof of my position as a Post-Glacial flood. Of this debacle he says: "It is to the first rising of the waters that I attribute the destruction of the Mammoth and the Woolly Rhinoceros, and probably of Palæolithic man in Europe. The evidence is perhaps not so conclusive with regard to Palæolithic man, but as concerns the two great quadrupeds it is clear and decisive. I can find nowhere in Europe a trace of their existence after the first rise of the waters. In the great debacle their bones were carried and spread out over the low grounds along with the lowland gravel, and, doubtless, often carried into the top of low-lying patches of Boulder-clay, but in these cases they are broken, single, or rolled" (Belt, *op. cit.* p. 89).

Sporadic inundations and floods are also postulated over and over again in the pages of Mr. Geikie as periodical effects of the melting of ice, etc.; but the fact is, if we are to find a cause which operated uniformly from the Yellow Sea to the Atlantic, and left no traces of intermittent action great or small, but uniform unstratified mantles of deposit, marking one substantive and supreme cause, we must forego these local and fragmentary predicates, and postulate one overwhelming flood, such as is demanded by the evidence we have collected from other sources. I propose, in another paper, to deal with the so-called Diluvium of the French and Russian writers, and its correlated deposits.

Note.—I would add from Mr. Belt's paper, another example of the occurrence of *a skeleton* of what was doubtless a Mammoth to those already cited in a former paper. He says, "It is related that when, in the Thirty Years' War, the Swedes were besieging Krems, they found in one of their trenches the skeleton of a monstrous animal, and that besiegers and besieged ceased from their warfare for a time to gaze on the huge teeth of the giant that had been dug up" (*op. cit.* p. 73).

NOTICES OF MEMOIRS.

Classification of the Dinosauria. By Prof. O. C. Marsh, M.A., F.G.S.[1]

In the May number of the American Journal of Science (p. 423), I presented an outline of a classification of the Jurassic Dinosaurian Reptiles of this country which I had personally examined. The series then investigated is deposited in the Museum of Yale College, and consists of several hundred individuals, many of them well preserved, and representing numerous genera and species. To ascertain how far the classification proposed would apply to the material gathered from wider fields, I have since examined various

[1] Read before the National Academy of Sciences, at the Philadelphia meeting, November 14, 1881.

Dinosaurian remains from other formations of this country, and likewise, during the past summer, have visited most of the museums of Europe that contain important specimens of this group. Although the investigation is not yet completed, I have thought the results already attained of sufficient interest to present to the Academy at this time.

In previous classifications, which were based upon very limited material compared with what is now available, the Dinosaurs were very generally regarded as an order. Various characters were assigned to the group by Von Meyer, who applied to it the term *Pachypoda*; by Owen, who subsequently gave the name *Dinosauria*, now in general use: and also by Huxley, who more recently proposed the name *Ornithoscelida*, and who first appreciated the great importance of the group. and the close relation it bears to Birds. The researches of Leidy and Cope in this country, and Hulke, Seeley, and others in Europe, have likewise added much to our knowledge of the subject.

An examination of any considerable portion of the Dinosaurian remains now known will make it evident to any one familiar with reptiles, recent or extinct, that this group should be regarded, not as an order, but as a sub-class, and this rank is given it in the present communication. The great number of subordinate divisions in the group, and the remarkable diversity among those already discovered, indicate that many new forms will yet be found. Even among those now known, there is a much greater difference in size and in osseous structure than in any other sub-class of vertebrates, with the single exception of the placental Mammals. Compared with the Marsupials, living and extinct, the *Dinosauria* show an equal diversity of structure, and variations in size from by far the largest land animals known—fifty or sixty feet long—down to some of the smallest, a few inches only in length.

According to present evidence, the Dinosaurs were confined entirely to the Mesozoic age. They were abundant in the Triassic, culminated in the Jurassic, and continued in diminishing numbers to the end of the Cretaceous period, when they became extinct. The great variety of forms that flourished in the Triassic render it more than probable that some members of the group existed in the Permian period, and their remains may be brought to light at any time.

The Triassic Dinosaurs, although so very numerous, are known to-day mainly from footprints and fragmentary osseous remains. Not more than half a dozen skeletons, at all complete, have been secured from deposits of this period; hence, many of the remains described cannot at present be referred to their appropriate divisions in the group.

From the Jurassic period, however, during which Dinosaurian reptiles reached their zenith in size and numbers, representatives of no less than four well-marked orders are now so well known that different families and genera can be very accurately determined, and almost the entire osseous structure of typical examples, at least, be made out with certainty. The main difficulty at present with the

Jurassic Dinosaurs is in ascertaining the affinities of the diminutive forms which appear to approach Birds so closely. These forms were not rare, but their remains hitherto found are mostly fragmentary, and can with difficulty be distinguished from those of Birds, which occur in the same beds. Future discoveries will, without doubt, throw much light upon this point.

Comparatively little is yet known of Cretaceous Dinosaurs, although many have been described from incomplete specimens. All of these appear to have been of large size, but much inferior in this respect to the gigantic forms of the previous period. The remains best preserved show that, before extinction, some members of the group became quite highly specialized.

Regarding the Dinosaurs as a sub-class of the Reptilia, the forms best known at present may be classified as follows:—

Sub-Class DINOSAURIA.

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 vertebræ by suture or ankylosis; 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; tibia with procnemial crest; fibula complete. First row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint.

(1.) Order Sauropoda (Lizard foot). Herbivorous.

Feet plantigrade, ungulate; five digits in manus and pes; second row of carpals and tarsals unossified. Pubes projecting in front, and united distally by cartilage; no post-pubis. Precaudal vertebræ hollow. Fore and hind limbs nearly equal; limb bones solid. Sternal bones parial. Premaxillaries with teeth.

(1) Family *Atlantosauridæ*. Anterior vertebræ opisthocœlian. Ischia directed downward, with extremities meeting on median line.

Genera *Atlantosaurus, Apatosaurus, Brontosaurus, Diplodocus, ? Camarasaurus* (*Amphicœlias*), *? Dystrophæus*.

(2) Family *Morosauridæ*. Anterior vertebræ opisthocœlian. Ischia directed backward, with sides meeting on median line.

Genus *Morosaurus*.

European forms of this order: *Bothriospondylus, Cetiosaurus, Chondrosteosaurus, Eucamerotus, Ornithopsis, Pelorosaurus*.

(2.) Order Stegosauria (Plated lizard). Herbivorous.

Feet plantigrade, ungulate; five digits in manus and pes; second row of carpals unossified. Pubes projecting free in front; post-pubis present. Fore limbs very small; locomotion mainly on hind limbs. Vertebræ and limb bones solid. Osseous dermal armour.

(1) Family *Stegosauridæ*. Vertebræ biconcave. Neural canal in sacrum expanded into large chamber; ischia directed backward, with sides meeting on median line. Astragalus coössified with tibia; metapodials very short.

Genera *Stegosaurus* (*Hypsirhophus*), *Diracodon*, and in Europe, *Omosaurus*, Owen.

(2) Family *Scelidosauridæ*. Astragalus not coössified with tibia; metatarsals elongated; four functional digits in pes. Known forms all European.

Genera *Scelidosaurus*, *Acanthopholis*, *Cratæomus*, *Hylæosaurus*, *Polacanthus*.

(3.) Order ORNITHOPODA (Bird foot). Herbivorous.

Feet digitigrade, five functional digits in manus and three in pes. Pubes projecting free in front; post-pubis present. Vertebræ solid. Fore limbs small; limb bones hollow. Premaxillaries edentulous in front.

(1) Family *Camptonotidæ*. Clavicles wanting; post-pubis complete.

Genera *Camptonotus*, *Laosaurus*, *Nanosaurus*, and in Europe *Hypsilophodon*.

(2) Family *Iguanodontidæ*. Clavicles present; post-pubis incomplete. Premaxillaries edentulous. Known forms all European.

Genera *Iguanodon*, *Vectisaurus*.

(3) Family *Hadrosauridæ*. Teeth in several rows, forming with use a tessellated grinding surface. Anterior vertebræ opisthocœlian.

Genera *Hadrosaurus*, *? Agathaumas*, *Cionodon*.

(4.) Order THEROPODA (Beast foot). Carnivorous.

Feet digitigrade; digits with prehensile claws. Pubes projecting downward, and coössified distally. Vertebræ more or less cavernous. Fore limbs very small; limb bones hollow. Premaxillaries with teeth.

(1) Family *Megalosauridæ*. Vertebræ biconcave. Pubes slender, and united distally. Astragalus with ascending process. Five digits in manus and four in pes.

Genera *Megalosaurus* (*Poikilopleuron*), from Europe. *Allosaurus*, *Cœlosaurus*, *Creosaurus*, *Dryptosaurus* (*Lælaps*).

(2) Family *Zanclodontidæ*. Vertebræ biconcave. Pubes broad elongate plates, with anterior margins united. Astragalus without ascending process; five digits in manus and pes. Known forms European.

Genera *Zanclodon*, *? Teratosaurus*.

(3) Family *Amphisauridæ*. Vertebræ biconcave. Pubes rod-like; five digits in manus and three in pes.

Genera *Amphisaurus* (*Megadactylus*), *? Bathygnathus*, *? Clepsysaurus*; and in Europe, *Palæosaurus*, *Thecodontosaurus*.

(4) Family *Labrosauridæ*. Anterior vertebræ strongly opisthocœlian, and cavernous. Metatarsals much elongated. Pubes slender, with anterior margins united.

Genus *Labrosaurus*.

Sub-Order Cœluria (Hollow tail).

(5) Family *Cœluridæ.* Bones of skeleton pneumatic or hollow. Anterior cervical vertebræ opisthocœlian, remainder biconcave. Metatarsals very long and slender.

Genus *Cœlurus.*

Sub-Order Compsognatha.

(6) Family *Compsognathidæ.*—Anterior vertebræ opisthocœlian. Three functional digits in manus and pes. Ischia with long symphysis on median line. Only known specimen European.

Genus *Compsognathus.*

DINOSAURIA?

(5.) Order Hallopoda (Leaping foot). Carnivorous?

Feet digitigrade, unguiculate; three digits in pes; metatarsals greatly elongated; calcaneum much produced backward. Fore limbs very small. Vertebræ and limb bones hollow. Vertebræ biconcave.

Family *Hallopodidæ.*

Genus *Hallopus.*

The five orders defined above, which I had previously established for the reception of the American Jurassic Dinosaurs, appear to be all natural groups, well marked in general from each other. The European Dinosaurs from deposits of corresponding age fall readily into the same divisions, and, in some cases, admirably supplement the series indicated by the American forms. The more important remains from other formations in this country and in Europe, so far as their characters have been made out, may likewise be referred with tolerable certainty to the same orders.

The three orders of Herbivorous Dinosaurs, although widely different in their typical forms, show, as might be expected, indications of approximation in some of their aberrant genera. The *Sauropoda,* for example, with *Atlantosaurus* and *Brontosaurus,* of gigantic size, for their most characteristic members, have in *Morosaurus* a branch leading toward the *Stegosauria.* The latter order, likewise, although its type genus is in many respects the most strongly marked division of the Dinosaurs, has in *Scelidosaurus* a form with some features pointing strongly towards the *Ornithopoda.*

The Carnivorous *Dinosauria* now best known may all be placed at present in a single order, and this is widely separated from those that include the herbivorous forms. The two sub-orders defined include very aberrant forms. which show many points of resemblance to Mesozoic Birds. Among the more fragmentary remains belonging to this order, but not included in the present classification, this resemblance appears to be carried much farther.

The order *Hallopoda,* which I have here referred to the *Dinosauria,* with doubt, differs from all the known members of that group in having the hind feet especially adapted for leaping, the metatarsals being half as long as the tibia, and the calcaneum produced far backward. This difference in the tarsus, however, is not greater than

may be found in a single order of Mammals, and is no more than might be expected in a sub-class of Reptiles.

Among the families included in the present classification, I have retained three named by Huxley (*Scelidosauridæ*, *Iguanodontidæ*, and *Megalosauridæ*),[1] although their limits as here defined are somewhat different from those first given. The sub-order *Compsognatha*, also, was established by that author in the same memoir, which contains all the more important facts then known in regard to the *Dinosauria*. With the exception of the *Hadrosauridæ*, named by Cope, the other families above described were established by the writer.

The *Amphisauridæ* and the *Zanclodontidæ*, the most generalized families of the *Dinosauria*, are only known from the Trias. The genus *Dystrophæus*, referred provisionally to the *Sauropoda*, is likewise from deposits of that age. The typical genera, however, of all the orders and sub-orders are Jurassic forms, and on these especially the present classification is based. The *Hadrosauridæ* are the only family confined to the Cretaceous. Above this formation there appears to be at present no satisfactory evidence of the existence of any *Dinosauria*.

REVIEWS.

I.—The Water Supply of England and Wales. By Charles E. De Rance, Assoc. Inst. C.E., F.G.S., etc. Royal 8vo. pp. 623; 6 Coloured Maps. (London: Edward Stanford, 1882.)

THE necessity of a ready and easily accessible water supply has been probably the most common cause (although other causes may have sometimes operated) in determining the sites of habitations, villages, and towns in former times.

Professor Prestwich has shown that the early growth of London followed unerringly the water-bearing gravel (from 10 to 20 feet in thickness) of the Thames Valley, eastwards towards Bow, Whitechapel, and Stepney; north-eastwards towards Clapton, Hackney, and Newington, and westwards towards Kensington and Chelsea; while northward it came for many years to a sudden termination where this bed of gravel ends abruptly and the London Clay comes to the surface, and occupies all the ground to the north. On the outskirts of London, a succession of villages grew up on the great beds of gravel ranging on the east, on the north along the Lea Valley, on the west, and on the south of the Thames, while the old habitations of Hampstead and Highgate are due to the water-bearing Bagshot Sands which cap these elevations; again, where the permeable gravel of the Boulder-clay series covers the London Clay hills to the north, we have the old settlements of Hendon, Finchley, Barnet, and other villages. (Ann. Address Geol. Soc. 1872, pp. 29–31.)

The extension of Metropolitan London upon an increased water supply is clearly indicated by the coloured Map given by Mr. De Rance (p. 179), showing the areas built upon at different dates from

[1] Quart. Journ. Geol. Society of London, vol. xxvi. p. 34, 1870.