5.—*Records of Self-registering Instruments.*

* An examination should be made of the records of self-registering instruments within or near the disturbed area—particularly of recording barometers, magnetic and tidal apparatus—with a view to determine the effects of the shock on these instruments, and also to ascertain by their means the exact time of occurrence.

While answers to any of the above questions would be useful in the study of an earthquake, especial pains should, if possible, be taken to determine accurately the time at which the principal shock occurs. Immediately it is felt, the time should be noted to the nearest second, and written down at once, a few seconds (to be ascertained by trial) being allowed for taking out the watch and reading off the time. As soon afterwards as possible, the watch used should be compared with an accurately regulated clock. But if this cannot be done, if the record cannot be relied on as correct to within a small fraction of a minute, a less close approximation cannot as a rule possess much value. The chief use of such a record is then to determine the epoch of the shock; and, in a matter of this kind, when two consecutive shocks in a given district may be separated by an interval of several years, a question of a few minutes, more or less, is of very little moment.

Next in importance to time-observations are those on the intensity of a shock. Without the aid of delicate instruments it is of course impossible to estimate the intensity with accuracy. But good results have been obtained by the use of a rough scale, according to which the intensity is determined by its effect on men and their dwellings. The following is the Rossi-Forel scale,[1] which is widely adopted by Italian and Swiss seismologists:—

Rossi-Forel Scale of Intensity.

I. Micro-seismometric shock: noted by a single seismograph, or by some seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

II. Extremely feeble shock: recorded by seismographs of different kinds; felt by a small number of persons at rest.

III. Very feeble shock: felt by several persons at rest; strong enough for the duration or the direction to be appreciable.

IV. Feeble shock: felt by persons in motion; disturbance of movable objects, doors, windows; cracking of ceilings.

V. Shock of moderate intensity: felt generally by everyone; disturbance of furniture and beds, ringing of some bells.

VI. Fairly strong shock: general awakening of those asleep; general ringing of bells, oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs; some startled persons leave their dwellings.

VII. Strong shock: overthrow of movable objects; fall of plaster; ringing of church bells; general panic, without damage to buildings.

VIII. Very strong shock: fall of chimneys, cracks in the walls of buildings.

IX. Extremely strong shock: partial or total destruction of some buildings.

X. Shock of extreme intensity: great disasters, ruins; disturbance of strata; fissures in the earth's crust; rock-falls from mountains.

Results to be expected.—It may be useful, in conclusion, to point out some of the results we may expect to obtain from a systematic study of earthquakes in this country.

The mere indication of the occurrence of a shock felt at a given place on a given day is of service in the compilation of earthquake statistics, and will tend to give completeness to our seismic record. With the help of such a record we can study the laws of the periodicity and geographical distribution of earthquakes. The time is past for drawing up chronological tables of shocks felt over the whole earth; but the importance of making our records complete for a definite area of study is becoming more and more evident.

The accurate determination of the time of occurrence in different places is of the very highest importance. Such observations, if sufficiently numerous, will help us in investigating the position of the area which constitutes the epicentrum; the way in which the vibrations are propagated outwards from the epicentrum; the velocity of the earth-wave, and the laws according to which the velocity varies with the distance from the origin. A knowledge of the time will also determine the question of the coincidence of shocks in distant areas, separated by a region in which the shock is not felt at all, and of other phenomena which may seem to be more or less intimately connected with the earthquake.

By a study of the intensity in the different parts of the disturbed area, we are enabled to draw one or more isoseismal lines with a fair approach to accuracy. From the form of these lines we can ascertain the approximate position of the epicentrum; and, from the relative distances between consecutive pairs of such lines, we can determine the way in which the intensity decreases as the earth-wave radiates from the origin, and the relations of this decrease with the form and geological structure of the ground.

The chief point to which our researches at present tend is thus the discovery of the position of seismic foci. But our ultimate object is something higher than and beyond all this. With certain exceptions, the slightest earthquake that occurs must indicate the site and mark the epoch of a step in the process of terrestrial evolution. To determine the laws of seismic distribution in space and time would therefore be to discover, in part, the laws that regulate the development of the earth's great surface-features. The study of earthquakes is fascinating enough in itself, but it acquires a loftier significance when viewed in its wider relations; for through it we may press forward to the solution of the great problem of geology—the origin and growth of mountain-chains.

[1] *Arch. des Sc. phys. et nat.*, 3me pèr. t. xi. pp. 148–149; Fouqué, "Les Tremblements de Terre," p. 22 (footnote); *Bull. del Vulc. ital.*, anno iv. (1877), pp. 39–40.

THE HORNED DINOSAURS OF THE UNITED STATES.

IN vol. xxviii. of NATURE (pp. 439 and 515), an account was given by Prof. Moseley of the magnificent skeletons of Iguanodons now mounted in the Brussels Museum of Natural History, which were at that time regarded as among the most remarkable of that extinct group of giant reptiles commonly known as Dinosaurs. Since that date, however, we have been gradually—thanks to the indefatigable labours of the transatlantic palæontologists—acquiring a fuller knowledge of the representatives of this curious group, of which the remains are preserved in such fine condition in the Secondary rocks of the United States Within the last few years, from the writings of Profs. Marsh and Cope—and more especially the excellent figures by which those of the former are illustrated—we have acquired so much information as to the form and structure of the gigantic Jurassic species belonging to the Sauropodous sub-order of the Dinosaurs—such as *Brontosaurus*—that we have begun to regard these extinct creatures as old friends (or should we rather say enemies?) and to flatter ourselves that our knowledge of the whole class is well nigh complete.

Recent discoveries in the topmost Cretaceous or Laramie deposits of North America have, however, brought to light the existence of a group of Dinosaurs, hitherto only very imperfectly known, which are remarkable, not only on

account of their gigantic dimensions, but as being the most bizarre and uncouth-looking forms which palæontology has yet brought to our notice. These are the so-called horned Dinosaurs of the Laramie, in regard to which several important memoirs have been published both by Prof. Cope and Prof. Marsh. There is, however, unfortunately some difference of opinion between these two eminent palæontologists as to the comparatively trivial point of the proper nomenclature to be applied to the various genera; and we must not be supposed to prejudge this question if we adopt the names employed by Prof. Marsh, to whom we are indebted for our illustrations.

As their name implies, one of the most striking features in the organization of these uncouth monsters is the presence of large horn-cores on the skull, as shown in Fig. 1.

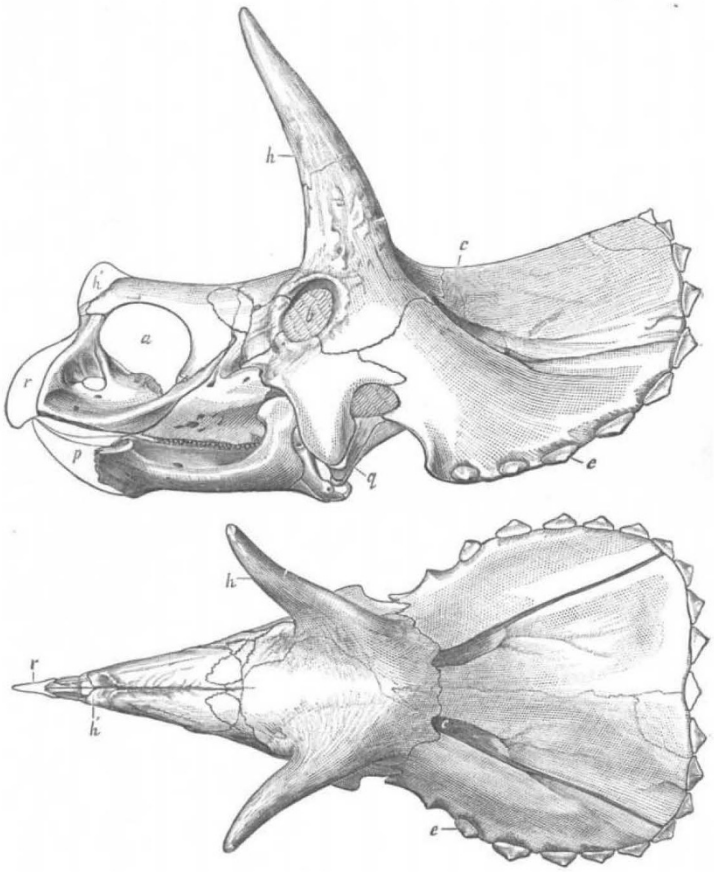

FIG. 1.—Left lateral and superior aspects of the skull of *Triceratops flabellatus*; from the Cretaceous of the United States. $\frac{1}{20}$ nat. size. *a*, nostril; *b*, eye; *c*, supratemporal fossa; *e*, epoccipital bone; *h*, frontal, and *h'*, nasal horn-core; *p*, predentary bone; *q*, quadrate bone; *r*, rostral bone. (After Marsh.)

These horn-cores are so like those of the oxen that some detached specimens found lying on the surface of the ground were actually described as belonging to an extinct bison.

The type of skull of which we give a figure belongs to the best known genus, for which Prof. Marsh proposes the name of *Triceratops*. It is remarkable not only for its gigantic size—the length of the figured specimen, which is said to indicate an immature individual, being about six feet—but also for its peculiar armature and structure. An imperfect skull of another species exceeds these dimensions, huge as they are, and is estimated when entire to have had a length of over eight feet. No other known animals, except whales, have a skull making any approach to these dimensions; that of the huge *Brontosaurus* being very small in comparison with the bulk of its owner. The skull of *Triceratops* is remarkable for its wedge-like form when viewed from above, and carries a pair of large horn-cores immediately over the eyes, and a short and single core above the nose. During life it may be inferred with a high degree of probability that these cores were sheathed with horn, like those of oxen, and that they proved equally effective weapons of defence. Equally remarkable is the huge flange-like expansion of the posterior region of the skull, evidently necessary for the attachment of muscles sufficiently powerful to support such a ponderous structure; and it is also peculiar for the presence of an *epoccipital* bone (*e*), which is quite unknown in all other animals. The structure of the teeth is somewhat similar to that obtaining in *Iguanodon*, but each tooth has two distinct roots. As in the latter, the extremity of the lower jaw is devoid of teeth, and likewise has a separate predentary bone at its extremity. The upper jaw is, however, quite peculiar in having a distinct toothless *rostral* bone at the extremity of the premaxillæ. It would thus seem probable that the mouth of these reptiles formed a kind of beak sheathed in horn like that of a tortoise. In young individuals the nasal horn-core is a separate ossification, but in the adult it becomes firmly anchylosed to the underlying bones; so that in this respect we have a precise analogy with the horn-cores of the giraffe. The brain of the creature is very minute—relatively smaller, indeed, than in any known vertebrate; this, however, might have been expected from the size of the brain in other Dinosaurs, since, in the same groups, large animals always have relatively smaller brains than their smaller allies.

Besides mentioning that the limb-bones resemble those of the armed Dinosaurs known as *Stegosaurus*, the only other portion of the skeleton to which we shall allude is the pelvis, of which a representation is given in Fig. 2. In this portion of the skeleton the haunch-bone or ilium (*il*) is remarkable for its great extension both in front of and behind the cavity, or acetabulum (*a*), for the head of the thigh-bone; and also for its horizontal or roof-like expansion, which is in marked contrast to the vertical plate-like form which is assumed by this bone in most other members of the order. With one important exception, the general contour of the pubis and ischium also comes nearest to that found in *Stegosaurus;* this being especially shown in the relation of the former bone to the ilium, and in the shape of the plate which it gives off to form the inner wall of the acetabulum. The remarkable exception is, however, that whereas in *Stegosaurus*, *Iguanodon*, and all other allied forms the pubis gives off a long backwardly projecting process running parallel with the ischium, in the present form there is no trace of any such process.

Mainly from the absence of this postacetabular process of the pubis, Prof. Marsh is disposed to regard the horned Dinosaurs as constituting a distinct primary group of the order; equivalent to those generally known as Sauropoda, Theropoda, and Ornithopoda. The resemblance in the structure of the limb-bones, and in a less degree that of the pelvis, to the loricated forms known as *Stegosaurus*, together with the nature of the dentition, render it, however, far more probable that we should regard these strange reptiles as peculiarly modified forms referable to the sub-order Ornithopoda—the group which includes *Iguanodon* and *Stegosaurus*. In the

course of his description Prof. Marsh remarks that, from the relatively large size of the humerus, the horned Dinosaurs were evidently quadrupedal; and since the presence of a postacetabular process to the pubis is evidently (as exemplified in birds and *Iguanodon*) in some way connected with the bipedal progression, it may be a fair inference that, owing to the resumption of a quadrupedal progression in the forms under consideration, this process has been lost. We may note that the pubis of *Triceratops* seems undoubtedly to correspond with the pre-acetabular portion of the pubis of *Stegosaurus*, and not with the pubis of *Megalosaurus*, which represents the postacetabular portion of the latter.

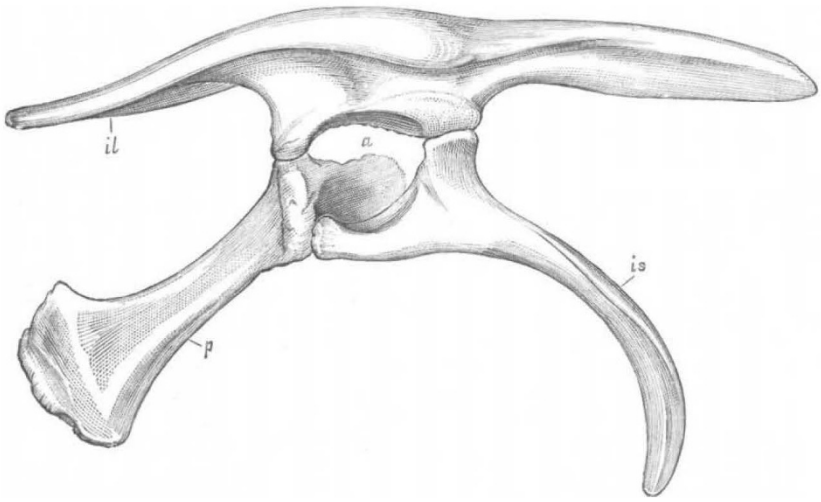

FIG. 2.—Left lateral aspect of the pelvis of *Triceratops flabellatus*. $\frac{1}{12}$ nat. size. *a*, acetabulum; *il*, ilium; *p*, pubis; *is*, ischium. (After Marsh.)

The nature of the dentition clearly shows that the horned Dinosaurs of the Laramie were of herbivorous habits, and as it seems impossible that any carnivorous Dinosaurs could have successfully waged war against such giants, we may fairly regard them as the lords of the plain in the distant Cretaceous epoch.

In conclusion we may venture to express the hope that future "finds" will enable the palæontologists of the United States to give us ere long a complete restoration of the skeleton of these mighty denizens of a long-past epoch.

R. L.

THE MEETING OF THE BRITISH ASSOCIATION AT LEEDS.

ON September 3 the sixtieth meeting of the British Association will be opened at Leeds by the President-elect, Sir F. A. Abel, F.R.S. The address, the lectures to the Association, and that to the operative classes will be delivered in the Coliseum, in which upwards of 3400 persons can be well and easily accommodated. By the courtesy of the Mayor and Corporation, the Victoria Hall will be used as the reception-room, and other rooms in the Town Hall will be provided for the various offices. Excellent Section rooms within short distances of the Town Hall have been secured by the kindness of various public and private bodies.

A guide-book, giving an account of the geology, history, places of interest, and manufactures of Leeds and the district, has been prepared, and a list of lodgings and hotel-accommodation has been drawn up. Various facilities are offered by the railway companies.

His Worship the Mayor of Leeds proposes to invite the members and associates to a reception and *conversazione* in the Municipal Art Gallery; a *soirée* will be given by the Executive Committee; and an afternoon reception at the Yorkshire College.

From the facility of access due to its central position in the railway system, from the number and variety of its industries, and from the beauty and interest of the country by which it is surrounded, Leeds offers exceptional advantages to visitors, of which many eminent members and foreign men of science have already expressed their intention of availing themselves.

Members interested in applied science and manufactures will be able by the courtesy of employers of labour to acquaint themselves with most of the modern processes by which the wealth of England is being augmented. They will be able to follow the smelting and working of iron until it is converted from clay-ironstone and hematite into tools, engines, pumps, textile machinery, and, in short, into everything which can be made of iron or mild steel. They can inspect the modern improvements in the old industry of Leeds by which wool, shoddy, and mungo are converted or reconverted into woollens or worsteds, and subsequently into clothes. Tanning, boot and shoe making, brewing, and the manufacture of sanitary, fire-resisting, and artistic earthenware employ a large number of hands; while among minor industries may be noted the manufacture of sulphuric acid and other chemicals, of bottles, of paper, of soap, of matches, and of soda-water.

Those interested in geology or scenery will find on the coast and in the diversified strata exposed, much that will instruct and interest them; while, to the historian, the architect, and the archæologist, the minsters, the cathedrals, the abbeys, the churches, the castles, the Roman remains, and the historic houses will furnish many objects worthy of attention.

Excursions may be taken or will be organized, in many cases by invitation, to most of the following places:—Add Church, Kirkstall Abbey, Temple Newsam, Farnley Hall, Harewood House, Boston Spa, Low Moor Iron-works, Pontefract Castle, the Ruskin Museum, Walton Hall and Wakefield, Aldborough, Beverley Minster, Bolton Abbey and Skipton, Castle Howard, Ingleborough, Harrogate, Hemsley and Rivaulx Abbey, Malham Tarn and Gordale Scar, Richmond, Ripon Cathedral and Fountains Abbey, Settle and the Victoria Cave, Scarborough and the coast, Wensleydale, and York.