

THE UPPER CRETACEOUS IGUANODONT
DINOSAURS.

DISCOVERIES of the last few years in Wyoming and Montana have thrown a flood of light upon the great herbivorous dinosaurs of the Upper Cretaceous which Joseph Leidy named *Trachodon*, so that now they are by far the most completely understood group of the dinosaurs, not excepting the famous iguanodonts of the Wealden or Lower Cretaceous of Bernissart.

It has long been known that *Trachodon* is readily distinguished by the elaborate and compound nature of its multiple grinding teeth, which present as great an advance upon those of *Iguanodon* as the teeth of *Equus* do upon those of the Eocene *Orohippus*; but there prove to be other characters indicative of the fact that *Trachodon* followed a fundamentally different line of evolution from that initiated by *Iguanodon*, or by the nearly contemporary, closely related *Camptosaurus* of America. These true Lower Cretaceous iguanodonts are probably typical terrestrial forms, as shown in the familiar restorations of the Bernissart specimens, possessing a short manus with the first digit set well apart, as if adapted to grasping the branches of trees or shrubs, or to supporting the animal while browsing.

Trachodon also has been represented as a terrestrial animal. One of the skeletons mounted under the direction of Mr. F. A. Lucas in the United States National Museum, and another mounted under the direction of the late Prof. Charles E. Beecher in the Yale Museum, represent the animal in a walking or running position, using the tail as a balancing organ. On the other hand, Mr. Barnum Brown, who has been the leader of the American Museum expeditions, under the writer's direction, to the Laramie or Upper Cretaceous of northern Montana since 1902, is convinced that these animals were principally aquatic or swimming forms, which used the tail chiefly for propulsion through the water, a view shared by Mr. Charles H. Sternberg, another field explorer. It may be added parenthetically that observation in the field often affords the most important indications as to mode of life.

It will be interesting to discuss the question of the appearance and habits of these animals from materials in the American Museum, which are being very thoroughly studied by Mr. Brown in preparation for a memoir. Of the two skeletons represented in the accompanying photograph (Fig. 1), this museum has acquired three skeletons. The one mounted in the quadrupedal pose (Fig. 1) was discovered in South Dakota, north-east of the Black Hills, by Dr. J. L. Wortman, in 1882, while collecting for Prof. Cope. It had been complete, and the skeleton was surrounded by impressions of the skin, most of which were destroyed during excavation. Some epidermal parts were pre-

served on the broad bill, showing an interlocking, tooth-like series of points on the horny sheath. As the skeleton lay in the rocks a stream had cut through it, carrying away both femora, most of the pelvis, and twelve presacral vertebræ. The erect specimen (Fig. 1) was found in central Montana by Mr. Oscar Hunter in 1904, and originally "swapped" for a "six-shooter" revolver. In 1906 it was purchased by the American Museum and excavated by Mr. Brown. An important feature of this skeleton was that the vertebral column was connected throughout, and all the bones which the Cope specimen lacked were preserved, together with both lower jaws and two bones of the skull; the

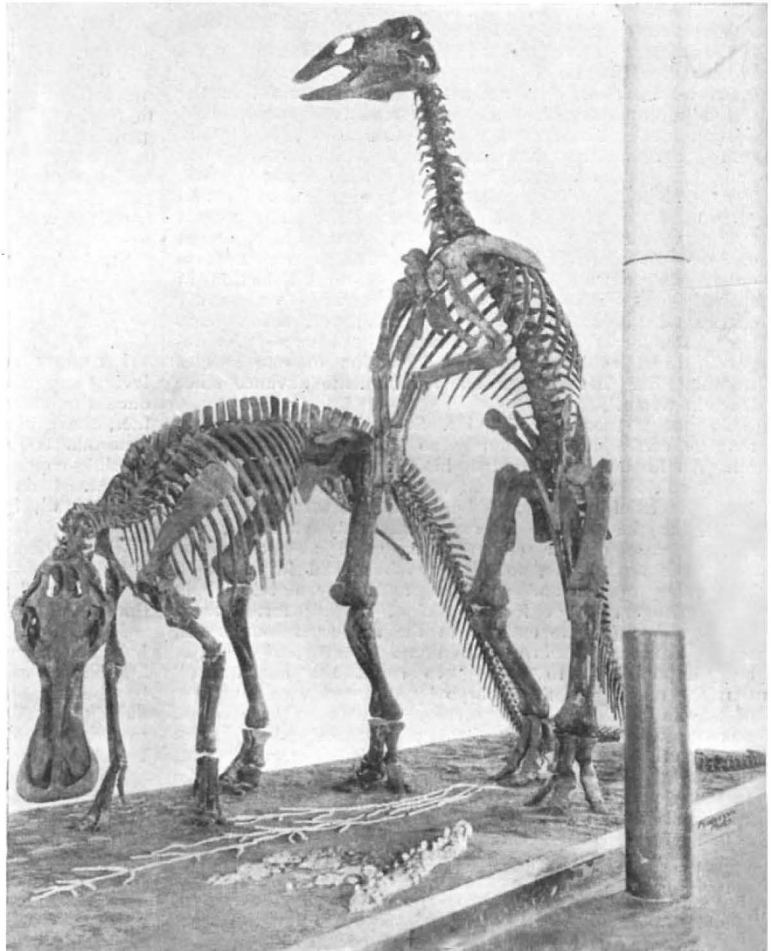


FIG. 1.—Oblique front view of two specimens of *Trachodon mirabilis* as mounted in the American Museum of Natural History.

rest of the skull is restored after the Cope specimen. In both specimens the tip of the tail is missing.

The difference in the preservation of these two animals partly controlled the design which has been adopted for the mounting; the animal with the perfect head, well known through the descriptions and figures of Cope as *Diclonius mirabilis*, is represented in a feeding posture, which brings the head where it can readily be examined, while the imperfect skull of the second skeleton is "skied" where it cannot be seen. The conception of this group takes us back to the close of the Cretaceous period, when trachodonts were among the most numerous of dinosaurs; as two of

them are feeding along the marshes, one is startled by the approach of a carnivorous enemy, *Tyrannosaurus*, and stands on tip-toe better to overlook the foliage; the other, unaware of danger, continues browsing. On the base of the group are shown impressions of leaves, fruit, wood, and shells, replicas of fossils actually associated with the bones of *Trachodon*. The leaves of the ginkgos, natives of China, were mingled with the cones of *Sequoia*, or big tree of California. Horsetail (*Equisetum*) rushes were abundant and luxuriant in growth, an imperfect specimen here represented measuring sixteen feet in length. Fruit and leaves of the fig are also abundant, and with the leaves of a species of banana and numerous palms attest a warm climate in the northern United States during the period.

Hardly was this carefully studied group completed late in 1907 when the fortunate discovery was made in Converse County, Wyoming, in August, 1908, by Messrs. Charles and George Sternberg, father and son, of another specimen of *Trachodon* with the epidermal impressions very extensively preserved. This completes our knowledge of the animal. Among many other new features it especially brings out the very important difference between the fore feet of *Trachodon* and of *Iguanodon*. As noted above, the manus of

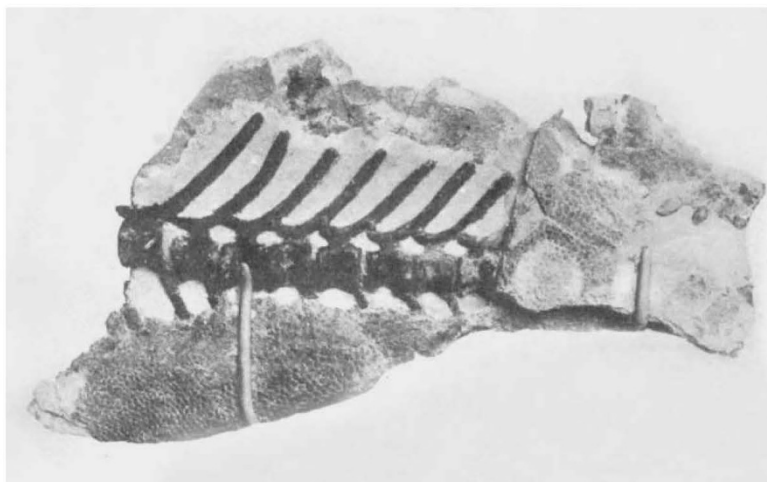


FIG. 2.—A portion of the tail of *Trachodon mirabilis* preserving the pavement epidermal scales.

Iguanodon is a short organ with grasping function. In *Trachodon* the manus is long and very slender; the thumb, or first digit, is not free, but closely appressed to the side, and still more remarkable is the fact that the entire hand was encased in an epidermal web, so that the digits are not freely movable, but closely united, and thus strongly indicative of a paddle function while moving in the water. This bears directly on the question whether these animals were aquatic, amphibious, or terrestrial. The terrestrial theory may apply to *Iguanodon*, but certainly not to these animals. The littoral or amphibious theory was that held by Prof. Cope. The familiar restoration by Charles R. Knight, which was made under his personal direction, represents one *Trachodon* on the shore in a sitting position, a second wading and feeding in shallow water. The enormously powerful hind limbs, provided with three large digits incased in hoofs, together with the long lines of osseous tendons connecting the vertebrae of the back with the vertebrae of the tail, both point to capacity for land progression on the hind limbs, with the use of the tail as a balancing organ.

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No habitually swimming animal would retain such limbs or acquire such inflexibility of a large region of the backbone as is suggested by the ossification of the tendons. On the other hand, river-frequenting or littoral habits are indicated first by the webbed nature of the epidermis on the fore feet, as well as by the observation of Mr. Brown that of all Upper Cretaceous dinosaurs these are the only ones the remains of which are found in off-shore marine deposits. This fact may be cited as a proof, either that they frequented shallow- and still-water bays of the sea, or that their remains were carried seaward in rivers.

The position selected for the group accordingly represents these animals as on a ripple-marked shore; one, the Cope specimen, in the quadrupedal position, with the tips of the digits of the manus lightly resting on the ground rather as balancers than as supporters. This is the first time an *iguanodont* has ever been mounted or represented in this position, and the justification for it is found in the fact that the fore limbs do readily reach the ground and terminate in expanded phalanges, which indicates the retention and occasional use of hoofs. If the *trachodons* in this phylum had never assumed a quadrupedal position, or used the fore limbs in this way, it is safe to infer that the limbs would have been either still more reduced and degenerate, or else the digits would have spread or expanded into true swimming paddles.

This method of mounting two or more specimens together, but in different poses to illustrate the supposed habits of feeding and of locomotion, is one which is being generally adopted. In the present case it brings out in side and rear views every important feature in the osteology of these animals. By an accident the tail in both these specimens terminates at the same point, but in other specimens in the Yale and National Museums smaller terminal vertebrae have been found which would add about five feet to the tail beyond the parts preserved in these specimens.

The actual height of the head above the ground in the standing *Trachodon* is seventeen feet; the total length of the body is thirty feet. Remains of still larger in-

dividuals of this species have been found which indicate greater height and length.

It is first of all evident from these skeletons and models that these *Trachodons*, like all the *iguanodonts*, were full-chested and slim-wasted, to use the terms of fashion; while the longitudinal diameter of the pelvic region is enormous, the vertical diameter is very slight. Thus the proportions of the abdominal girdle directly reverse those of the *Sauropoda* and carnivorous dinosaurs, in which the vertical diameter is the greatest. The shape of the chest is exactly preserved in the new Sternberg specimen, as well as in the indications of the muscular outlines of the limbs and of the presence of a dermal frill on the neck and anterior part of the back. The neck and chest regions are relatively short. The gape of the mouth is placed exactly at the front of the great rows of grinding teeth, as in the mammals. There is evidence that the skin was thrown into loose folds at the junction of the arms and legs with the body, as well as on the sides of the chest.

The *Trachodon* with the epidermal impressions was

found in the region of Converse County, Wyoming, made famous by the explorations of Hatcher for remains of the great horned dinosaurs or *Ceratopsia*. The entire animal lay in a normal position on its back. The left fore limb was outstretched at right angles to the body, while the right fore limb lay stretched over the under surface of the head. The hind limbs were drawn up and doubled on themselves. The hinder portion of the pelvis and the entire tail had been removed by erosion. The epidermal impressions are best shown on the throat and anterior part of the neck, on the arms and fore limbs, the entire right side of the body, including the axillary region, and especially over the abdomen. The skin is inflected like a curtain over the entire abdominal region without a single break, with brilliant impressions of the scale pattern. This abdominal infolding, the close appression of the skin to the surface of the bones, and the sharp transverse folds all indicate that after death the body was exposed for a long time to the sun, and the muscles and viscera became completely dehydrated; in other words, the body became thoroughly dried and mummified, while the epidermis became hardened and leathery under the action of the sun. In this condition the dinosaur mummy was caught in a freshet, and rapidly buried in fine river sand, which took a perfect cast of the epidermal markings before the tissues disintegrated under the solvent action of the water.

There is no evidence in any part of the epidermis either of coarse tubercles or of overlapping scales; on the contrary, the epidermis is extremely thin, and the markings are very fine for an animal of such large dimensions. In all parts of the body observed, the epidermis is covered with scales of two kinds—namely, smaller tubercular scales and larger pavement or non-imbricating scales. The latter are perfectly smooth, and, as grouped in clusters or rosettes, assume a rounded or irregularly polygonal form. Over the throat, neck, sides, and ventral surface these clusters are regularly disposed in different patterns, separated by rows of finer tubercular scales, but in the tail, as indicated in the specimen of *Trachodon mirabilis* (Fig. 2), it is probable that the cluster arrangement disappears, and that the entire tail is covered with the tessellated or pavement scales. The vigorous use of the tail among *Iguanodontia* as a balancing, and perhaps partly as a swimming, organ would lead us to expect this strong development of the scales in the tail region. This disposition of the scales into larger pavement groups and smaller tubercular rows is unlike that observed by the writer in any *Lacertilia*; it appears to be unique.

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NATURE STUDIES IN NEW ZEALAND AND AT HOME.¹

(1) MR. THOMSON is well known among zoologists by his discovery of *Anaspides*, a very interesting genus of Crustacea, on Mount Wellington, Tasmania. In this volume he has collected observations made in the neighbourhood of Dunedin during the last thirty years. The articles appeared originally in the *New Zealand Press*, and were obviously written without any intention of subsequent issue in volume form. They are necessarily somewhat slight, and touch upon a great variety of topics without systematic treatment. Yet they possess a value which often attaches to first-hand observation written down at the time, for the animals and plants of the island are undergoing a rapid change. Destruction of the bush and the importation of a European element has transformed the neighbourhood, not only of Dunedin, but of other parts of New Zealand. The indigenous plants, insects, and birds are, in many places, be-



A Marten moving along a Bough. Photo. by Mr. Douglas English. From "The Nature Book."

coming scarce, or have disappeared, and only a few more tenacious or more resistant have survived the process of change which has accompanied the development of the South Island. Hence these notes of garden and field life will be of interest to all who are anxious to preserve records of older societies, whether of animals or plants. It would be of the greatest interest to discover how rapidly and completely the introduced flora and fauna acquire the new periodicity of the seasons in New Zealand, and Mr. Thomson's notes may give the requisite stimulus to observers for further investigation on the indigenous and alien organisms of that country.

(2) This work has already appeared in serial form, and will prove a welcome gift-book to many a budding naturalist. The illustrations are excellent, and bring

¹ (1) "A New Zealand Naturalist's Calendar." Notes by the Wayside. By Geo. M. Thomson. Pp. 224. (Dunedin: R. J. Stark and Co., 1909.)

(2) "The Nature Book." A Popular Description by Pen and Camera of the Delights and Beauties of the Open Air. Vol. ii. Pp. iv+373-752. (London: Cassell and Co., Ltd., 1909.) Price 12s. net.

(3) "The Book of Nature Study." Vol. iii. Edited by Prof. J. Bretland Farmer. Pp. 228. (London: Caxton Publishing Co., n.d.) Price 7s. 6d.