sivalensis by the same characters, and by the plastron being connected to the carapace by suture and not by ligament.

Apparently the fossil now described represents a new species; it would therefore be well to designate it *Nicoria headonensis*. This, we believe, is the first record of the genus from England. At the present day *Nicoria* is found in the East Indies and Central and South America.

NOTICES OF MEMOIRS, ETC.

On the Significance of Pneumatic Foramina in Fossil Bones.

IN a paper "On a Pneumatic Type of Vertebra from the Lower Karroo Rocks of Cape Colony" (Ann. & Mag. Nat. Hist., ser. VII, vol. xiv, November, 1904, pp. 336–344), by Professor H. G. Seeley, F.R.S., the author makes (on p. 341) some interesting remarks on pneumatic foramina in fossil bones which appear sufficiently important to reproduce here:—

"Doubt has of late been current concerning the significance of pneumatic foramina in fossil bones, and is put forward verbally and in print by Professor H. F. Osborn. In an article in the *Century Magazine* for September, 1904, similar in scope to the lecture given at Cambridge in August to the British Association, he enunciates the same views. Writing of *Ornitholestes*, Professor Osborn remarks:—'Externally its bones are simple and solid-looking, but, as a matter of fact, they are mere shells, the walls being hardly thicker than paper, the entire interior of the bone having been removed by the action of the same marvellous law of adaptation which sculptured the vertebræ of its huge contemporaries. There is no evidence, however, that these hollow bones were filled with air from the lungs, as is the case of the bones of birds.'

"*Ornitholestes* is compared with *Cœlurus*, *Hallopus*, *Ornithomimus*, and *Aristosuchus*. It is known from the skull, forty-five vertebræ, pelvis, and representative parts of both fore and hind limbs of one individual (Bull. Am. Mus. Nat. Hist., vol. xix, p. 459). But from the context quoted I gather that the author's conclusions should be applied, not only to *Ornitholestes*, but to the pneumatic vertebræ of the largest Dinosaurs, possibly to all fossil pneumatic bones which are not referable to birds.

"The current belief that a pneumatic vertebral column is evidence of the prolongation into the bones of air-cells from the lungs is an inductive conclusion, based upon the evidence from the parallel condition in the bones of birds. This evidence is affirmed by Professor Osborn, in the passage quoted, not to exist, and in place of it he offers what is termed the 'Law of Adaptation' as having sculptured these huge vertebræ. I have met with no enunciation of this law; and until it is explained how it differs in physiological action from the processes which sculpture or excavate the bones of birds, it will be difficult to judge whether we are offered a law,

a suggestion, or only words, for no law will produce anatomical effects without corresponding physiological circumstances to sculpture the bones.

"If the influence of pneumatic pressure produces a well-known osteological result in excavation of a bone in a bird, what is there in the vertebræ of a Dinosaur to suggest that similar effects have been produced by dissimilar causes? And it would be interesting to find in an extinct order of animals evidence that an agency unconnected with the lungs produced results which differ from those in birds only in being the effect of larger areas of pressure acting laterally upon the sides of the vertebræ. But the evidence that there was any essential difference in the origin of these structures in Dinosaurs and birds is not forthcoming; and if it ever existed is lost with the soft parts of the animal.

"Nevertheless, cavities are formed in certain bones in animals of varied organization, which are not connected with the lungs in the manner of air-cells of birds, but they are chiefly in the skull. They are slightly developed in existing reptiles, but are most conspicuous in warm-blooded animals. The skulls of elephants exhibit a maximum development of pneumatic cavities which have no connexion with the lungs, and the texture of these bones closely approximates to that of cellular vertebræ in some Cetiosaurian Dinosaurs, such as *Ornithopsis* and its American representatives. The resemblance between the mammal skull and the reptile vertebra is one of analogy. There are no facts to support the inference that the cause which *expanded* the cranial bones of the elephant and other mammals is identical with that which absorbed and excavated the bony tissue, but did not augment the size of the cervical and dorsal vertebræ of Dinosaurs. There is no basis for comparison between the conditions in mammals and these extinct reptiles, for no mammal shows a pneumatic vertebral column which can be compared with these Dinosaurs; and when a mammalian vertebra is hollow it is not comparable, since there is no pneumatic foramen.

"On the other hand, Dinosaurs are not conspicuous for pneumatic cavities in bones of the skull, and there are therefore no facts to suggest the idea that they might by analogy develop a pneumatic vertebral column which was not connected with the lungs, even if the cranial and vertebral pneumatic structures had been comparable.

"The influence of the lungs as a whole in modifying the vertebral column of a reptile is manifest in the dorsal vertebræ of Testudinata. In tortoises, under conditions of terrestrial life, the lungs have expanded and given the carapace a remarkable elevation. At the same time the neural arches have become raised, and the lungs have pressed evenly against the sides of the centra of the vertebræ till they have become narrowed into thin plates by the tissue being absorbed laterally. But the lung never penetrates into the substance of the vertebra or excavates holes in the bones in existing reptiles comparable to those seen in skeletons of Dinosaurs, Ornithosaurs, and birds.

"The influence of the lungs on the vertebral column of a Dinosaur as distinct from the air-cells may be, perhaps, inferred from the elevated condition of the neural arch and upward direction of transverse processes under which the lungs extended in such a type as *Diplodocus*, described by Professor Osborn and the late Dr. J. B. Hatcher. It is reasonable to infer that the lungs were so large that their intermittent upward pressure stimulated the growth of the neuro-central suture to form the high neural arch; but as they were not confined by an unyielding envelope in the same way that the carapace confines the lungs of tortoises, there is but little lateral compression of the body of a vertebra as a consequence of absorption, which was localized laterally about the pneumatic foramen.

"All down the vertebral column in *Diplodocus* the vertebræ are excavated, and the lateral holes were termed by Dr. Hatcher pleuro-central cavities. They have been well described in *Ornithopsis*. Their distinctive feature is that in the dorsal region the lateral foramina expand within the centrum into large chambers separated by a median vertical longitudinal partition, and each is commonly divided into unequal anterior and posterior parts by an imperfect vertical transverse lamina of bone. From this primary lateral cavity bone-cells commonly extend to the articular faces of the centrum and other parts of the vertebra. This condition of the pneumatic vertebræ is only dissimilar to that of birds in its details. In no existing animals except birds is a similar pneumatic structure found in the vertebral column, and it is only known in connexion with air-cells prolonged from the lungs. There is no fact to suggest that the lungs themselves were extended into the pleuro-central cavities of Dinosaurs: such an idea is not consistent with the pneumatic condition of the vertebræ in the elongated neck and tail. But with the general resemblance to the condition in the bones of birds it has been inferred that the pneumatic pressure, which was persistent enough to absorb the bone locally and laterally, was greater in Dinosaurs than in birds, because the cavities excavated are larger. Although this pressure, judged by its effects, was most potent in the dorsal region of the lungs, it also extended to the neck and tail, as in certain birds. It is therefore inferred that no cause is known except prolongation of air-cells from the lungs into the bones which is capable of producing these results, for from no other source in nature is the pressure derived which penetrates in this way into the skeleton.

"This is inductive evidence from physiology and comparative anatomy. In place of it Professor Osborn has offered nothing except the following passage:—'The dominating principle in construction of the backbone is maximum strength with minimum weight. The ingenuity of sculpture by which this is brought about, every single vertebra differing from its fellow, baffles the Lamarckian as well as the Darwinian, and tempts us to revive the old teleological explanation.'[1] Teleology is not known as an element in science, and explains nothing."

[1] Memoirs American Museum of Natural History, vol. i, part 5, p. 193, "A Skeleton of *Diplodocus*."