

Portion of tooth of *Mosasaurus*, from the Upper Chalk of Norwich, exhibited by Mr. B. B. WOODWARD, F.G.S.

Recent Conglomeratic Boulder (pebbles in clay), from the Isle of Wight, exhibited by Mr. E. LITCHFIELD.

A SYNOPSIS OF THE VERTEBRATE FOSSILS OF THE ENGLISH CHALK.

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I. INTRODUCTION.

Since the publication of the revised edition of Dixon's 'Geology and Fossils of Sussex,' in 1878, no synoptical review of the vertebrate fossils of the English Chalk appears to have been attempted; and with the exception of the elaborate (though not critical) synopsis of genera in Mr. Etheridge's new edition of Phillips' 'Manual,' students of Cretaceous palæontology can still find no other concise treatise on the subject. Much advance, however, has been made within the last ten years in our knowledge of later Mesozoic life; and I propose in the present communication to offer a brief epitome of the facts in regard to the Vertebrata of the period, yielded by the well-known uppermost division of the Mesozoic strata in Western Europe. The 'Proceedings' of the Association afford a most appropriate medium for the publication of such a review, so many of the Members being interested in the treasures continually disinterred from the numerous chalk pits of the South of England. And I have fortunately been able to compare with all that has been written the unrivalled series of original specimens in the British Museum, and the collection of Henry Willett, Esq., F.G.S., of Brighton, besides many other fossils in the Museum of Practical Geology, Jermyn Street, the Woodwardian Museum, Cambridge, and the private cabinets of Mr. S. J. Hawkins, F.G.S., and other Members of this Association.

The following account is thus, to a certain extent, an independent revision of the old vertebrate fauna in question; though it must be admitted that the magnitude of the subject renders it necessarily sketchy and incomplete. If, however, it enables the fortunate discoverers of such fossils the more readily to determine them, and to

recognize the value of certain specimens as throwing light upon various still obscure points, this slight endeavour may not be without value in palæontological progress; and I have attempted, as far as possible, to unravel synonymy and correct old errors resulting from the study of imperfect material. The summary of the literature of the subject is also as yet a desideratum, and to make this tolerably complete the title of each work or memoir is quoted *in extenso* upon its first mention, though subsequently abbreviated.

In the midst of so much that is technical it will be impossible to enter at length into many general questions or elementary considerations; and before consulting the descriptive notices of the various fossils it will thus be necessary for those who are not already versed in the rudiments of vertebrate anatomy and zoology to study some elementary treatise on the subject, in addition, if possible, to the articles upon Fishes and Reptiles in the new (ninth) edition of the 'Encyclopædia Britannica.' Dr. Albert Günther's 'Introduction to the Study of Fishes' (Edinburgh, 1880) is also an indispensable work of reference in connection with the Class of which it treats.

II. FOSSIL REPTILES OF THE CHALK.

The Reptilian remains of the Chalk are only few and fragmentary, but there are representatives of all the orders characteristic of later Mesozoic times, except the Crocodilia.

Order CHELONIA.

As might be expected, the Chelonian remains of the Chalk appear to be all referable to allies of the Turtles, adapted for marine life. The first trace of the order in the English Chalk was recognized in 1836, by Dr. Buckland, who briefly noticed the broken symphysis of a mandible from Dr. Mantell's collection, in his 'Bridgewater Treatise.'*

Genus *Chelone*, A. Brongniart.

To the genus *Chelone* itself may probably be referred the fragmentary remains of a large Turtle, nearly, if not quite, equalling

* Rev. W. Buckland, 'Geology and Mineralogy,' 2nd edit., 1837, Vol. ii, p. 67, Pl. xlv, Fig. 3d.

in size the *Chelone Hoffmanni** (= *C. Camperi*, Owen) of Maasricht. Prof. (Sir Richard) Owen has, indeed, provisionally associated some English fossils † with this species; and these include two large plates of the carapace (considered as probably "marginals"), besides a connected series of five other marginals, and two ribs and costal plates, all from the Chalk of Kent. Limb-bones, and probably jaws, of Turtles, have also been discovered in the same beds.

Genus *Cimoliochelys* (Owen), A. S. W.

In 1841‡ Prof. (Sir Richard) Owen described four marginal plates of a small Chelonian, from the Chalk of Burham, Kent, as probably "referable to that family of Chelonia which lives in fresh-water or estuaries;" about the same time,§ Dr. Mantell made known the almost entire carapace, and parts of the plastron, of the same animal, under the name of *Emys Benstedii*; and somewhat later,|| Owen examined the new materials, and arrived at the conclusion that they indicated a truly marine form, which must be referred either to *Chelone* or to "a new sub-genus (*Cimochelys*) of marine Turtles having a closer affinity to the Emydes than the typical species." Still later,¶ a detailed description and discussion of all available specimens led to the conclusion that, though small, the fossils pertained to adult individuals, and that there could be no longer any doubt as to their marine character.

The carapace of the Chelonian in question is oval in shape, with a pointed posterior extremity, and no known specimens are more than six inches in length. The marginal plates are well-developed, but the costals, eight in number,** are not complete, thus leaving fon-

* For detailed description and figures of this species see T. C. Winkler, 'Des Tortues fossiles conservées dans le Musée Teyler,' 1869. Since the reading of the present paper Dr. Georg Baur ('Science,' Vol. xi, 1888, p. 144) has proposed to place *C. Hoffmanni* in a distinct genus, *Allopleuron*, on account of the small development of the costal plates and the slenderness of the marginals.

† R. Owen, "Monograph of the Fossil Reptilia of the Cretaceous Formations," 'Mon. Pal. Soc.,' 1851, pp. 9-11, Pl. v. Also R. Owen, 'History of British Fossil Reptiles,' Vol. i, p. 163; Vol. ii, Pls. 45, 46 (Chelonia), Pl. ix, Figs. 5, 6 (Lacertilia).

‡ R. Owen, "Description of the Remains of a Chelonian Reptile from the Chalk," 'Trans. Geol. Soc.' [2], Vol. vi (1842), p. 412, Pl. xxxix, Fig. 5.

§ G. A. Mantell, "On the Fossil Remains of Turtles discovered in the Chalk Formation of the S. E. of England," 'Phil. Trans.,' 1841, pp. 153-158, Pls. xi, xii.

|| R. Owen, "Report on British Fossil Reptiles," Part ii. 'Rep. Brit. Assoc.,' 1841, p. 176.

¶ R. Owen, 'Mon. Foss. Rept. Cret. Form.,' 1851, pp. 4-8, Pls. i.-iii.

** Wrongly shown as ten in Mantell's Pl. xii, Fig. 2, *loc. cit.*

tanelles between their extremities, as in the Turtles and in the young and immature individuals of Emydians and Tortoises. The plastron is no more complete than in the Turtle; and the coracoid bone also agrees with that of this marine type. The skull is still unknown, unless *Rhinochelys** eventually proves to be identical, and the limb-bones yet remain to be discovered.

It ought to be added that Rüttimeyer† regards these fossils as most probably immature individuals of freshwater forms. My colleague, Mr. G. A. Boulenger, however, considers that the shape of the carapace and the well-developed character of the marginal plates prove that the animals are adult, and unmistakably allied to the Turtles; while the narrowness of the neural plates and other features will render the adoption of Owen's distinct name, *Cimo[lio]chelys*, justifiable.

Though not hitherto detected, I am able to state that another Chelonian Chalk fossil has been figured by Dixon‡ as the jaw of a Sun-fish (*Orthagoriscus*). The specimen is preserved in the British Museum, and is undoubtedly the dentary bone of a Chelonian reptile; as suggested to me by Prof. Seeley, it probably belongs to the type in which the dentary bones are united at the symphysis by a persistent suture—a type already recognized in the Eocene Tertiaries.§

Order SAUROPTERYGIA.

Genus *Polyptychodon*, Owen.

Not uncommon fossils of the Chalk and other Cretaceous formations are some robust conical teeth, cylindrical in section, which have the enamelled surface of the crown ornamented by prominent, closely-set longitudinal ridges. To these, in 1841,|| Prof. (Sir

* H. G. Seeley, "Index to Fossil Reptilia, etc., Woodwardian Museum," 1869, p. 25. *R. pulchriceps* = *Chelone pulchriceps*, Owen, 'Mon. Foss. Rept. Cret. Form.,' 1851, p. 8, Pl. viia, Figs. 1-3.

† L. Rüttimeyer, "Ueber den Bau von Schale und Schädel bei lebenden und fossilen Schildkröten," 'Verh. naturf. Ges. Basel,' Vol. vi (1873), p. 118.

‡ F. Dixon, 'Foss. Suss.,' First edit., p. xiii, Pl. xxxii, Figs. 3, 4. *Orthagoriscus* is rightly omitted in Mr. E. T. Newton's list in the second edition; but the figure is still labelled as before, though erroneously stating that the specimen is "recent."

§ H. G. Seeley, "Note on some Chelonian Remains from the London Clay," 'Ann. and Mag. Nat. Hist.' [4], Vol. viii (1871), p. 231.

|| R. Owen, "Rep. Brit. Foss. Rept. ii," 'Brit. Assoc. Rept.,' 1841, p. 156. Also R. Owen, 'Odontography,' 1840-45, Vol. ii, p. 19, Pl. lxxii, Figs. 3, 4.

Richard) Owen applied the name of *Polyptychodon* (many-ridged tooth) in allusion to the last-named character; and our knowledge of the nature of the animal to which they belonged has since been increased by other discoveries, though much yet remains to be learned as to the minor features in its osteology. The teeth were originally referred to "*Sauria incertæ sedis*," but the subsequent discovery of a fragment of jaw showing their implantation in distinct sockets led to the reference of *Polyptychodon* to the crocodiles.* Some Saurian bones from the Lower Greensand of Hythe, Kent, were also regarded as probably belonging to the same animal,† though now known to be truly Dinosaurian.‡ And the still later discovery of a portion of the skull in association with the jaws and teeth, in the Chalk of Somersetshire, has shown that the genus is truly Sauropterygian, allied to *Plesiosaurus*.§ The characters of the vertebræ likewise support this determination.||

Two species are recognized, the teeth of *P. interruptus* being the commonest, and differing from those of *P. continuus* in "the greater proportion of the ridges which stop short of the apex of the crown." It remains uncertain, however, whether these variations in superficial markings did not occur in different parts of the dentition of the same individual. In the ordinary broken dental crowns the tooth-substance has often become resolved into superimposed conical layers by fracture.

Genus *Plesiosaurus*, Conybeare.

Teeth and vertebræ and other remains of Plesiosaurians, provisionally referred to *Plesiosaurus* itself, are occasionally met with in the Chalk, and Sir Richard Owen has named three supposed species, *P. Bernardi* (founded upon a cervical vertebra from the Upper Chalk of Houghton, near Arundel, Sussex),¶ *P. con-*

* R. Owen, in Dixon's 'Foss. Suss.,' 1850, pp. 378, 379, Pl. xxxvii, Figs. 16, 17; Pl. xxxviii, Fig. 3.

† R. Owen, 'Mon. Foss. Rept. Cret. Form.,' pp. 47-55, Pls. xii, xiii.

‡ *Dinodocus Mackesoni*, R. Owen, 'A History of British Fossil Reptiles,' Vol. ii, p. ix.

§ R. Owen, 'Mon. Foss. Rept. Cret. Form.,' Suppl. iii (1860), pp. 20-22, Pl. iv, Figs. 1-3.

|| R. Owen, *op. cit.*, Suppl. iii, pp. 22-25, Pl. v, Figs. 1, 2; Pl. vi. Also H. G. Seeley, "On an Associated Series of Cervical and Dorsal Vertebræ of *Polyptychodon*, from the Cambridge Upper Greensand," 'Quart. Journ. Geol. Soc.,' Vol. xxxii (1876), pp. 433-436.

¶ R. Owen, in Dixon's 'Foss. Suss.,' 1850, pp. 396-398, Pl. xl. Also 'Mon. Foss. Rept. Cret. Form.,' 1851, pp. 60, 61, Pl. xviii. Mr. William Davies permits me to state that he considers these and the other supposed Plesiosaurian bones as most probably referable to *Polyptychodon*.

strictus (represented by the centrum of a cervical vertebra from Steyning, Sussex),* and *P. Smithii* (to which are referred paddle-bones and a cervical vertebra from the Kentish Chalk†).

The tooth of *Plesiosaurus* is slender and cylindrical in section, and the enamelled crown is slightly curved, gradually tapering to a point; the surface is marked with longitudinal ridges of different lengths, none extending quite to the apex. The tooth is, in fact, essentially similar to that of *Polyptychodon*, though usually more elongate and slender.

Order ICHTHYOPTERYGIA.

Genus *Ichthyosaurus*, König.

The first remains of Ichthyosaurians discovered in the English Chalk were made known by Prof. (Sir Richard) Owen in 1839, ‡ who recorded a portion of a lower jaw, with teeth, from the Lower Chalk between Folkestone and Dover; but neither these fossils nor the teeth subsequently described and figured in Dixon's 'Fossils of Sussex' (p. 400, Pl. xxxix., Fig. 10), were considered as affording definite evidence of the specific distinctness of the animal from the Liassic *I. communis*. In 1845, § however, Mr. James Carter discovered more satisfactory specimens in the Lower Chalk of the neighbourhood of Cambridge, and these enabled him to refer it decidedly to a previously unknown species, named *I. campylodon*, in allusion to the strong inward curve of the crowns of the lower teeth. Still later, || Sir Richard Owen published detailed descriptions and figures of Mr. Carter's fossils, and of others discovered near Dover; so that the characters of the dentition, upper and lower jaws, and some of the vertebral centra, are now tolerably well known.

The teeth have round, longitudinally-ridged crowns, very similar

* R. Owen, in Dixon's 'Foss. Succ.', 1850, p. 398, Pl. xxxvii, Figs. 6, 7. Also 'Mon. Foss. Rept. Cret. Form.', 1851, pp. 61, 62, Pl. ix, Figs. 6, 7.

† R. Owen, 'Mon. Foss. Rept. Cret. Form.', 1851, pp. 63, 64, 66, 67, Pls. xvii, xix. The name appears to be first given in the Index to Vol. iv of Owen's 'Hist. Brit. Foss. Rept.', where the plates are repeated.

‡ R. Owen, "Rep. Brit. Foss. Rept., i," 'Brit. Assoc. Rep.', 1839, p. 126.

§ J. Carter, "Notice of the Jaws of an *Ichthyosaurus* from the Chalk in the neighbourhood of Cambridge," 'Brit. Assoc. Rep.', 1845, Trans. Sect., p. 60. Also J. Carter, "On a New Species of *Ichthyosaurus* in the Chalk," Charlesworth's 'London Geological Journal,' 1846, pp. 7-9.

|| R. Owen, 'Mon. Foss. Rept. Cret. Form.', 1851, pp. 69-80, Pl. iv, Figs. 1-10, 13-16, Pls. xxii, xxiii, xxv, xxvi.

to those of *Polyptychodon*; but they are readily distinguished by the great diameter of the base, which becomes compressed towards its lower extremity, and is not smooth but coarsely grooved.

Order PYTHONOMORPHA.

This is a group of marine reptiles, comprising the well-known *Mosasaurus* and its allies, placed by Owen* among the Lacertilia (Lizards), but regarded by Cope† as a distinct order, having Lacertilian affinities, though most nearly related to the Ophidia (Snakes). Very few remains have hitherto been met with in the English Chalk, but the discoveries of nearly complete skeletons in America and in Holland and Belgium have revealed all the more important features of its osteology. The first fossils detected in this country were some vertebræ from the Upper Chalk of Lewes, figured and described by Dr. Mantell, in 1833‡; and subsequent discoveries have been chronicled by Charlesworth, Owen, Bayfield,§ and others.

Genus *Mosasaurus*, Conybeare.

The teeth of the typical genus *Mosasaurus* have a conical crown fixed upon a stouter base, which is relatively long and ankylosed to the jaw-bones. The crown is smooth, enamelled, and more or less laterally compressed; and a pair of opposite longitudinal ridges divide it into two faces, which are sometimes of corresponding size though sometimes very unequal. Occasionally the sharp ridges exhibit feeble serrations. Teeth of all the varied forms met with in the *M. Camperi* (= *M. Hoffmanni*) of Maastricht, are discovered in the upper divisions of the English Chalk, and the numerous vertebræ occurring in the same beds are likewise closely similar to those of this well-known fossil.

Some of the teeth from the Norfolk Chalk were originally referred by Mantell|| "to an unknown reptile or to a sauroid fish," and they were first described under the name of *Leiodon anceps*, by

* R. Owen, 'On the Rank and Affinities of the Mosasauridæ,' 'Quart. Journ. Geol. Soc.,' Vol. xxxii (1877), pp. 682-715. Also *ibid.*, Vol. xxxiv (1878), pp. 748-752.

† E. D. Cope, "The Vertebrata of the Cretaceous Formations of the West," 'Rept. U.S. Geol. Surv. Territ.,' Vol. ii (1875), pp. 113-130.

‡ G. A. Mantell, 'Geology of the South-east of England,' 1833, p. 146.

§ T. G. Bayfield, "Discovery of the Skeleton of *Leiodon anceps* in the Chalk at Norwich," 'Geol. Mag.,' Vol. i (1864), p. 296.

|| G. A. Mantell, 'Wonders of Geology,' ed. 1839, Vol. i, p. 339.

Prof. (Sir Richard) Owen,* who felt justified in regarding the teeth with symmetrically compressed crowns as pertaining to the mandible and the maxilla, thus showing a generic divergence from the true *Mosasaurus*, in which the corresponding teeth (though not those of the pterygoid bones) have less compressed unsymmetrical crowns. At present, however, the evidence is not conclusive, and we prefer, with Mr. Edward Charlesworth, to place the specimens in the genus *Mosasaurus* itself, until the discovery of more satisfactory materials renders a certain determination possible.† There does not seem to be much proof of the generic identity of the more complete American and New Zealand Fossils subsequently referred by Cope‡ and Hector§ to *Leiodon*; and the English teeth must thus be known as *Mosasaurus anceps*. It is true that Charlesworth claims to have described one of the specimens figured by Owen (1840) at a British Association meeting in 1836, under the name of *M. stenodon*, but this must necessarily become a synonym since no printed notice appeared until ten years later.||

Another supposed Pythonomorph from the chalk of Offham, Sussex, was described by Owen, in 1850,¶ upon the evidence of the jaws and teeth. The type-specimen, however, is in the collection of Mr. Henry Willett, of Brighton, and, as recognized by Prof. O. C. Marsh and Mr. William Davies,** it really pertains to a large fish, *Pachyrhizodus*. The truly Mosasaurian vertebræ, ascribed in

* R. Owen, 'Odontography,' p. 261, Pl. lxxxii, Figs. 1, 2. Also 'Mon. Foss. Rept. Cret. Form,' 1851, pp. 42-45, Pl. ixa. R. Owen, "Restoration of *Leiodon anceps*," 'Ann. and Mag. Nat. Hist,' [5], Vol. iv (1878), pp. 53-61, Pl. viii; and 'Supplement to Restoration of *Leiodon anceps*,' *ibid.* [5], Vol. v, pp. 177-181, Pl. viii.

† Since the reading of this paper Mr. R. Lydekker has studied the known specimens, and is of opinion that the genus *Leiodon* ought to be adopted for the compressed teeth, while an uncertain Mosasaurian genus, perhaps *Clidastes*, is represented by the others.

‡ E. D. Cope, 'Vert. Cret. Form. West,' 1875, pp. 160-178; with plates.

§ J. Hector, "On the Fossil Reptilia of New Zealand," 'Trans. N. Zealand Instit.,' Vol. vi (1874), p. 351.

|| E. Charlesworth, "On the Occurrence of a species of *Mosasaurus* in the Chalk of England, and on the Discovery of Flint within the Pulp-cavities of its Teeth," 'London Geol. Journ.,' 1846, pp. 23-32, Pls. iv, v.

¶ R. Owen, in Dixon's 'Foss. Suss.,' pp. 380-383, Pl. xxxvii, Fig. 1. Also 'Mon. Foss. Rept. Cret. Form.,' 1851, pp. 31-35, Pl. ix, Fig. 1.

** For this unpublished information I am indebted to my friend, Mr. Edward Crane, F.G.S., Chairman of the Brighton Museum Committee. There can be no doubt as to the correctness of the amended interpretation of the fossil.

error to the possessor of these jaws,* may doubtless be referred to *M. anceps*.

Order LACERTILIA.

Remains apparently of true Lizards are rare in the Chalk, but Sir Richard Owen has recognized three extinct genera, *Rhaphiosaurus*, *Dolichosaurus*, and *Coniosaurus*.

Genus *Rhaphiosaurus*, Owen.

A fragment of mandible from the Lower Chalk, near Cambridge, forms the type-specimen of the genus and species, *Rhaphiosaurus subulidens*, Owen;† and no parts of the animal beyond jaws and teeth have hitherto been described. The teeth are slender and awl-shaped, hence the name of the genus. They are "attached by ankylosis in a single series to the bottom of a shallow alveolar groove, and to the inner side of an outer wall or parapet of the same groove, thus corresponding with that type of saurian dentition called 'pleurodont' among modern lizards." The published figures, however, regarded in the light of modern facts, are suggestive of considerable doubts as to the reptilian nature of the fossil.

Genus *Dolichosaurus*, Owen.

This genus is so named on account of its elongate snake-like form, and a tolerably complete skeleton, from the Lower Chalk of Burham, Kent, has been described by Sir Richard Owen.‡ The hinder portion of this fossil was at first provisionally associated with *Rhaphiosaurus*,§ and was presented by Sir Philip de M. Grey Egerton to the British Museum; the anterior portion has also been acquired for the National Collection, being one of the fine series of Burham fossils collected by the late Mrs. Smith, of Tunbridge Wells.

* R. Owen, in Dixon's 'Foss. Suss.,' pp. 383, 384, Pl. xxxvii, Figs. 2-5, Pl. xxxix, Figs. 7-9. Also 'Mon. Foss. Rept. Cret. Form.,' 1851, pp. 40, 41, Pl. viii, Figs. 1-3; Pl. ix, Figs. 2-5.

† *Rhaphiosaurus*, R. Owen, "Description of the Vertebral Column [etc.] of a small Lacertine Saurian from the Chalk," 'Trans. Geol. Soc.' [2], Vol. vi, (1840), p. 413, Pl. xxxix, Fig. 3. *R. subulidens*, Owen, 'Brit. Assoc. Rep.,' 1841, p. 190. *R. lucius*, Owen, Dixon's 'Foss. Suss.,' 1850, p. 385-6, Pl. xxxix, Figs. 1-3. *R. subulidens*, Owen, 'Mon. Foss. Rept. Cret. Form.,' 1851, pp. 19, 20, Pl. x, Fig. 5, 6.

‡ R. Owen, in Dixon's 'Foss. Suss.,' pp. 388-395, Pl. xxxviii, Figs. 1, 2; Pl. xxxix, Fig. 4. Also 'Mon. Foss. Rept. Cret. Form.,' pp. 22-29, Pl. x, Figs. 1-4.

§ R. Owen, 'Trans. Geol. Soc.' [2], Vol. vi (1840), p. 412, Pl. xxxix, Fig. 4.

The head of *Dolichosaurus* is relatively small, and the teeth are long smooth cones, with rounded blunt tips. The vertebræ are united by a "peg-and-socket" arrangement (zygosphene and zygantrum) of the neural arch,* such as is met with in Ophidia (snakes) and certain Pythonomorpha. The fore and hind limbs are well developed, and the single known species is named *D. longicollis*, in allusion to the great length of its neck. With regard to the affinities of the animal, Sir Richard Owen concludes that its skeleton exhibits all the characteristic features of a lizard. There is most divergence in the neck, where "the Ophidian type is rather followed in the number and size of the vertebræ, and in the size and shape of the ribs: a less decided approach, but one still indicating an affinity to the Ophidians, is made by the unusual length of the slender trunk, which includes, from the skull to the sacrum, not fewer than fifty-seven vertebræ, and is not less than eighteen inches in length. The smallness of the head accords with the long and slender proportions of the neck, and must have added to the snake-like appearance of this early example of procelian lizard. But the complete and typically Lacertian organization of the scapular and pelvic arches, and of their locomotive appendages, prove that the *Dolichosaurus* was more strictly a lacertine Saurian than the existing genera, *Pseudopus*, *Bipes*, and *Ophisaurus*, which effect the transition from the Lizards to the Snakes."

Genus *Coniosaurus*, Owen.

Coniosaurus crassidens, the only known species of this genus, was founded† upon fragments of the jaws and teeth, associated with vertebræ, from the Lower Chalk of Clayton, near Brighton. "The dentary bones contain from 18 to 20 teeth; the anterior five or six teeth are slender, slightly recurved, pointed or lanxiform; the rest progressively increase in thickness as they are placed further back, expanding above the neck, slightly compressed laterally, most convex inwardly, with an anterior border which is more prominent and curved than the posterior; the anterior margin is further characterized by a longitudinal groove on its outer side. Some of the posterior teeth show a slight longitudinal indent near the posterior obtuse border: and the last molar is smaller and

* H. G. Seeley, 'Phillips' Manual of Geology,' revised edit., Vol. i (1885), p. 512.

† R. Owen, i¹ Dixon's 'Foss. Suss.,' pp. 386-388, Pl. xxxvii, Fig. 18-20. Also 'Mon. Foss. Rept. Cret. Form.,' pp. 21, 22, Pl. ix, Figs. 13-15.

more obtuse than the others. The enamel is very finely wrinkled. The teeth are closely and rather obliquely arranged; the long simple roots are ankylosed to the bottom of the shallow alveolar groove and to the inner side of the outer wall."

Order PTEROSAURIA.

The hollow bones of the Pterodactyles are so fragile, that the remains of the Pterosaurian order discovered in the Chalk are all of a most fragmentary character. Up to the present time, no evidence of toothless forms like those from the American Cretaceous has been discovered in this formation, and all the English fossils may perhaps be referred to a single genus, *Ornithocheirus*.

Genus *Ornithocheirus*, Seeley.

The history of the acquisition of our still imperfect knowledge of Chalk Pterodactyles is long and intricate. The first relics of these animals, comprising the shaft of one long bone and the articular end of another from the Chalk of Kent, were described by Owen in 1840* as "*Ornitholites*," i.e., as referable to birds. Five years later Dr. Bowerbank† discovered a fragment of the jaws and teeth of an undoubted Pterodactyle, with portions of hollow limb-bones, in the Lower Chalk of Burham, and associating with these fossils the supposed bird-remains of Owen, proposed to name the new species thus indicated, *Pterodactylus giganteus*. Shortly afterwards, in 1846,‡ Prof. (Sir Richard) Owen re-affirmed his previous conclusions, and suggested that the "bird" might receive the name of *Cimoliornis diomedeus*, adopting as specific name the term used by Gervais § in alluding to these fossils as representing an "*Osteornis*."|| In 1847¶ Dr. Bowerbank made a further contribution to the subject, and four years later yet another,** adding a new species, *P. Cuvieri*, upon the evidence of a

* R. Owen, "Description of the Remains of a Bird from the Chalk," 'Trans. Geol. Soc.' [2], Vol. vi (1840), p. 411, Pl. xxxix, Figs. 1, 2.

† J. S. Bowerbank, "On a new species of Pterodactyl found in the Upper Chalk of Kent," 'Quart. Journ. Geol. Soc.,' Vol. ii (1846), pp. 7, 8, Pl. i.

‡ R. Owen, 'British Fossil Mammals and Birds,' 1846, pp. 545-548; woodcuts.

§ P. Gervais, 'Thèse sur les Oiseaux Fossiles,' 1844, p. 38 (according to Owen).

|| "This term is applied by M. Gervais, not generically to the fossil in question, but generally to all fossil bones of birds." (Owen.)

¶ J. S. Bowerbank, "Microscopical Observations on the structure of the Bones of *Pterodactylus giganteus* and other Fossil Animals," 'Quart. Journ. Geol. Soc.,' Vol. iv (1848), pp. 2-10, Pls. i, ii.

** J. S. Bowerbank, "On the Pterodactyles of the Chalk Formation," 'Proc. Zool. Soc.,' 1851, pp. 14-20, Pl. iv.

fragment of an elongated jaw, also from Burham. Meanwhile Sir Richard Owen acknowledged his original mistake, but first pointed out* that two species, a larger and a smaller, must have been included under *P. giganteus*; and believing that the latter name applied especially to the so-called "bird remains" which he had at first described, suggested that Dr. Bowerbank's earliest fragment of jaw and the smaller limb-bones should be named *P. conirostris*. In 1851,† however, recognizing the impossibility of definitely associating the various detached limb-bones with the jaws, Sir Richard Owen adopted the name of *P. giganteus* for the specimen he had termed *P. conirostris*, redescribed the jaw-fragment of *P. Cuvieri*, and made known portions of the snout of a third previously unrecognized species, *P. compressirostris*; he also added separate descriptions and figures of the limb-bones already discovered, under provisional determinations. No further contribution to the subject seems to have been made before 1870, when Prof. Seeley‡ definitely showed that there were similar fossils in the Cambridge Greensand and that these represented a genus quite distinct from *Pterodactylus*, which might be named *Ornithocheirus*. Among other important features, it was pointed out that the latter genus differed from the former in having the foremost pair of teeth projecting forward in the upper jaw, and placed at a higher level than all those behind. Sir Richard Owen's subsequent attempt§ to supplant the name *Ornithocheirus* (bird-hand) by the new term *Coloborhynchus* (stunted-snout), on account of the alleged inappropriateness of the first, is scarcely justifiable; and the Chalk species must therefore be known respectively as *Ornithocheirus giganteus*, *O. Cuvieri*, and *O. compressirostris*.

The bones of *Pterodactyles* may always be recognized by their hollowness and their very thin, extremely dense walls. The detached teeth are not readily distinguished from those of the fish *Protosphyræna*, found in the same beds; they are long, conical, and

* R. Owen, in Dixon's 'Foss. Suss.' pp. 401-404, Pl. xxxviii, Figs. 4-7.

† R. Owen, 'Mon. Foss. Rept. Cret. Form.', pp. 88-104, Pl. xxvii, Figs. 8-10; Pl. xxviii, Figs. 1-7; Pl. xxiv, xxx, xxxi. Also R. Owen, "On a new species of *Pterodactyle* (*Pterodactylus compressirostris*, Owen) from the Chalk; with some Remarks on the previously described species," 'Proc. Zool. Soc.', 1851, pp. 21-34.

‡ H. G. Seeley, 'The Ornithosauria,' 1870, pp. 28-94, 112-128. See also H. G. Seeley, "On Evidence of two new Ornithosaurians referable to the Genus *Ornithocheirus*, from the Upper Greensand of Cambridge," 'Geol. Mag.' [2] Vol. viii, 1881, pp. 13-20, Pl. i.

§ R. Owen, 'Mon. Foss. Rept. Mesoz. Form.,' Pt. 1, 1874, p. 6.

laterally compressed, with smooth or delicately striated enamelled crowns.

Order DINOSAURIA.

Genus *Acanthopholis*, Huxley.

The only Dinosaurian remains hitherto recorded from the English Chalk have been obtained from the Chalk Marl in the neighbourhood of Folkestone. These fossils indicate a small armoured animal, of a herbivorous character, allied to the Liassic *Scelidosaurus* and the Wealden *Hylæosaurus* and *Polacanthus*, and named by Prof. Huxley* *Acanthopholis horridus*. The type-specimens comprise the basioccipital and basisphenoid bones of the skull, three teeth, several vertebræ, portions of limb-bones, and numerous dermal scutes and spines, all found associated, and now preserved partly in the Museum of Practical Geology and partly in the British Museum. The teeth are triangular and compressed, with a deeply dentated margin; and they have the sides marked by radiating grooves, one extending downwards from each marginal notch. The scutes vary from oval discs, slightly raised in the middle, and hardly more than an inch in diameter, to great spines about nine inches in height, with a base measuring five inches in its longer axis; and the outer surface of all these is covered with irregular pits and branching grooves suggestive of the original presence of an enveloping soft integument. The vertebræ are slightly biconcave, and, so far as known, have been described in detail by Prof. Seeley.† The last-named palæontologist has also recorded (*loc. cit.*) other remains of *Acanthopholis* from the Cambridge Greensand.

III. FOSSIL FISHES OF THE CHALK.

The Upper Cretaceous Fishes are of great interest on account of the number of forms they include immediately ancestral to the families and genera of existing seas. In this later Mesozoic ichthyic fauna, the marine Ganoids were rapidly becoming extinct; the Selachians were apparently already differentiated into the families met with at the present day; while the Teleosteans were very largely of a primitive "generalized" type, though some,

* T. H. Huxley, "On *Acanthopholis horridus*, a New Reptile from the Chalk Marl," 'Geol. Mag.,' Vol. iv, 1867, pp. 65-67, pl. v.

† H. G. Seeley, "On the Vertebral Characters of *Acanthopholis horridus*, Huxley," 'Quart. Journ. Geol. Soc.,' Vol. xxxv, 1872, pp. 596-600. woodcuts.

like the Berycoids, had advanced to a considerable degree of "specialization."

Order SELACHII.

The Sharks and Rays form a well-characterized order, with a cartilaginous skeleton, having the upper jaw (pterygo-quadrate cartilage) free, and merely suspended to the skull. The teeth are attached only to the membrane enveloping the jaws, and the skin is often armed with dermal tubercles (the so-called "placoid scales") of essentially similar structure. Long spines are often present in front of the dorsal fins, or isolated upon the tail; and the latter is either straight and pointed (*diphycercal*) or at the same time upwardly bent, with an unsymmetrical tail-fin (*heterocercal*). The gill-slits are not covered externally with any fold of skin, and the mouth is rarely terminal, being nearly always placed inferiorly. The vertebral column sometimes remains in its primitive notochordal state, having only chondrified neural and hæmal arches; sometimes there are mere slender rings in the notochordal sheath; often the biconcave vertebral centra are complete. The latter are of three types, first described by Prof. Sir Richard Owen,* and afterwards more accurately determined and named by Dr. Carl Hasse, of Breslau.† In the first, or *cyclospondylic* type, each vertebra may be said to consist of two hollow cones placed end to end, thus generally having the external appearance of being much constricted in the middle; in the second, or *tectospondylic* type, concentric laminæ surround the primitive double-cone just mentioned; and in the third, or *asterospondylic* type, outwardly radiating plates are arranged round the double cone, more or less connected together by concentric laminæ, and giving a star-like appearance to transverse sections of the vertebræ. The "cyclospondylic" is evidently the primitive type, of which the two others are specialized modifications.

The Spiny Dog-fishes (*Spinacidæ*) are cyclospondylic; the Rays, *Pristiophoridae*, and Angel-fishes (*Squatinae*) are tectospondylic; and the *Lamnidae*, *Carchariidae*, *Cestraciontidae*, etc., are asterospondylic. It is thus possible to determine detached Selachian vertebræ approximately, and Dr. Hasse attempts to show that even the various genera and species can be identified.

* R. Owen, 'Anatomy of Vertebrates,' Vol. i, 1866, p. 32.

† C. Hasse, 'Das natürliche System der Elasmobranchier,' Jena, 1879-1882. See also K. A. Zittel's 'Handbuch der Palæontologie,' Vol. iii, pp. 61-63.

*Selachii Asterospondyli.*Genus *Notidanus*, Cuvier.

This primitive genus of sharks is occasionally represented in the English Chalk—especially in the higher beds—by detached teeth which vary somewhat in form, but apparently belong to a single well characterized species, *N. microdon*, Agass.,* and possibly in part to a second, *N. pectinatus*, Agass.† The lower lateral teeth are most commonly met with, and are easily recognized by their long comb-shaped form; the root has no fangs, but is straight and laterally compressed, and the crown consists of a series of sharp cones, similarly compressed, more or less oblique, placed one behind the other, and diminishing in size as they approach the hinder end. As is always the case in the genus *Notidanus*, the upper teeth are shorter than the lower, and those originally situated in front of the upper jaw often consist merely of a single large, backwardly directed cone, with one or two small denticles behind.‡

In *N. microdon*, the anterior edge of the foremost or principal cusp of the dental crown is slightly serrated, and I have observed no very marked accentuation of this character in any of the large series of Chalk teeth I have had the opportunity of examining, with the exception of a few from the front of the upper jaw. Agassiz, however, made known one example, probably from Sussex, in which the anterior serrations were represented by a series of distinct denticles, and for this type he proposed the name of *N. pectinatus*.

The detached teeth appear to be the only relics of *Notidanus* hitherto recognized in the English Chalk, but a tolerably complete fish, named *N. gracilis*, has been described from the Upper Cretaceous of Mount Lebanon.§

Genera *Hybodus*, Agassiz, and *Synechodus*, A. S. Woodw.

The characters of the teeth and dorsal fin-spines of *Hybodus* are so well known that it is unnecessary to describe them in detail. The

* L. Agassiz, 'Recherches sur les Poissons fossiles' (1833-1843), Vol. iii, p. 221, Pl. xxvii, Fig. 1; Pl. xxxvi, Figs. 1-2. A more extended description, with figures, is given in Smith Woodward, "On the Palæontology of the Selachian Genus *Notidanus*, Cuvier," 'Geol. Mag.' [3], Vol. iii (1886), p. 213, Pl. vi, Figs. 10-15.

† L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 221, Pl. xxxvi, Fig. 3. Mr. William Davies suggests that this may be an abnormal tooth of *N. microdon*—a very plausible idea.

‡ See figures in 'Geol. Mag.,' *loc. cit.*

§ J. W. Davis, "On the Fossil Fishes of the Chalk of Mount Lebanon, in Syria," 'Trans. Roy. Dublin Soc.' [2], Vol. iii (1887), pp. 470-1, Pl. xiv, Fig. 1.

Chalk fossils hitherto referred to this perhaps too comprehensive "genus," however, include considerable portions of the cartilaginous skeleton in addition to these less perishable structures, and the whole are suggestive of some interesting considerations in regard to the evolution of the Hybodont sharks. The typical fishes of the genus *Hybodus* from the Lias seem to have had a persistent notochord, while the best known Chalk species shows a well-developed vertebral column, with centra of the "asterospondylic" type; the skull of the later form is less primitive than that of the earlier, and the dentition is also more specialized, the front teeth being quite sharp and prehensile, while the posterior are nearly flat and adapted for crushing. These facts are revealed by the small "*Hybodus*" *dubrisiensis*,*—the only species yet defined from the English Chalk—and the well differentiated character of the vertebral column, among other features, warrants the generic separation of this form from its Jurassic progenitors under the name of *Synechodus*. Whether all the numerous detached teeth which have received names in Bohemia,† and the still unrecorded teeth from the English Chalk, all belong to the same genus, or to *Hybodus* proper, must yet remain undetermined; but it is significant to note that all the known dorsal fin-spines from the Chalk are smooth, the fragments of a ribbed spine described by Agassiz as *Hybodus sulcatus*, from "la craie de Lewes,"‡ being undoubtedly Wealden fossils, and not improbably belonging to *Hybodus basanus*.§

Genus *Drepanephorus*, Egerton.

In 1822 some spines and vertebræ from the Chalk of Lewes were referred by Dr. Mantell to the Teleostean "File-fish," *Balistes*.|| These were subsequently shown by Prof. Agassiz to be really the remains of a shark, and seemed to him to indicate a form so nearly allied to the living *Spinax* that he proposed the name of *Spinax*

* S. J. Mackie, "On a New Species of *Hybodus*, from the Lower Chalk," 'The Geologist,' Vol. vi (1863), pp. 241-246, Pl. xiii. Smith Woodward, "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*, Mackie)," 'Proc. Zool. Soc.,' 1886, pp. 218-224, Pl. xx.

† A. E. Reuss, 'Versteinerungen der böhmischen Kreideformation,' 1845-6. Pt. i, p. 2, Pl. ii, Fig. 20; Pt. ii, pp. 97, 98, Pl. xxi, Figs. 9-17; Pl. xxiv, Figs. 26-28; Pl. xlii, Fig. 7.

‡ L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 44, Pl. x6, Figs. 15, 16.

§ S. J. Mackie, *loc. cit.*, p. 242.

|| G. A. Mantell, 'Fossils of the South Downs,' 1822, p. 229, Pl. xxxiii, Figs. 5, 6.

major.* Still later, in 1850, Sir Philip Egerton described some scattered teeth from the Chalk which bore a very close resemblance to those of the living Port Jackson shark, *Cestracion*, and were thus made the type of a new species of that genus, named *Cestracion canaliculatus* in allusion to a small perforation or canal passing obliquely through the root.† In 1853 the discovery of more satisfactory specimens proved that the teeth made known by Egerton, and the spines previously described by Mantell and Agassiz, truly belonged to the same fish,‡ and nineteen years later, in 1872, Sir Philip Egerton reinvestigated the fossils, describing the dentition, spines, vertebral column, and portions of cartilage, and showing that they indicated a Selachian genus distinct from any previously determined.§ This new form he proposed to term *Drepanephorus* (sickle-bearer), and, following Agassiz, he placed it among the Spiny Dog-fishes in the *Spinacidae*. The subsequent elaborate researches of Dr. Carl Hasse upon the vertebræ have demonstrated that the fish ought rather to be referred to the *Cestraciontidae*,|| and still more recent studies seem to show that it can scarcely be distinguished from certain later Mesozoic Cestracionts, which have been described as *Acrodus*.¶

Of the fish with so long a history, numerous fragmentary relics are met with in the Chalk of almost all localities, as well as in the Gault and Greensand. The dorsal fin-spines are comparatively small, the largest examples not attaining a length of more than five inches; and each individual possessed two of these, one in front of either dorsal fin. These defences are laterally compressed, without posterior denticles, and have the exposed sides covered with smooth shining ganoine, only marked by delicate lines of growth. They exhibit varying degrees of curvature, some—generally the posterior—being nearly straight, and some—generally the anterior—quite sickle-shaped.

The teeth of *Drepanephorus* vary considerably in different parts

* L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 62, Pl. xb, Figs. 8-14.

† F. Dixon, 'Foss. Suss.,' p. 365, Pl. xxxii, Fig. 8.

‡ Sir P. Egerton, "Palichthyologic Notes," 'Quart. Journ. Geol. Soc.,' Vol. ix (1853), p. 281.

§ Sir Philip Egerton, "Figs. and Descrips. Brit. Org. Remains," Dec. xiii ('Mem. Geol. Surv.,' 1872), Pl. ix.

|| C. Hasse, "Paläontologische Streifzüge im British Museum," 'Neues Jahrb.,' 1883, Vol. ii, p. 66.

¶ e.g., *Acrodus falcifer*, A. Wagner, 'Abh. k. Bayer. Akad. Wiss.,' Cl. ii, Vol. ix pp. 300-4, Pl. v, Fig. 1.

of the jaw, being arranged exactly as in the living *Cestracion*, the more prehensile anteriorly, and the crushing teeth behind. Each of the former consists of a smooth, sharply-pointed cone, with a pair of large lateral denticles, fixed upon a massive root or base, while the latter are elongate and flattened, with a longitudinal median ridge, from either side of which there descend fine rugæ, passing more or less abruptly into a complex and delicate ornamental network. In the typical species, *D. canaliculatus*, the root of the tooth, as already mentioned, is pierced by an oblique perforation; but I have been unable to ascertain whether such is the case in the larger specimens described by Agassiz under the name of *Acrodus rugosus*,* which may belong to a distinct species.†

Genus *Acrodus*, Agassiz.

No teeth belonging to the familiar type of *Acrodus* as represented in the Lias, have hitherto been detected in the Chalk, and the most recent examples of this dental form are those of *A. levis*, from the Gault.‡ Some detached teeth have, however, been referred to this genus, and it is impossible to determine, upon such evidence alone, whether forms like Dixon's *A. Illingworthi*§ are not rightly placed here. These teeth sometimes attain a considerable size, more than an inch in length, and many are quite indistinguishable from those usually referred to *Hybodus*; but the discovery of much more satisfactory material must be awaited before any satisfactory determination of these remains can be attempted.

The so-called *Acrodus cretaceus*, Dixon, may almost certainly be referred to *Drepanophorus canaliculatus*||; and *A. rugosus*, Agass., as already remarked, belongs either to the same species, or to a larger form of *Drepanophorus* as yet unrecognized.

Genus *Oxyrhina*, Agassiz.

This is a shark so nearly related to *Lamna* that zoologists ordinarily place the single living species in the latter genus. Agassiz,

* L. Agassiz, 'Poiss. Foss.' Vol. iii, p. 148, Pl. xxii, Figs. 28, 29.

† Smith Woodward, "Notes on some Post-Liassic Species of *Acrodus*," 'Geol. Mag.' [3], Vol. iv (1887), p. 104.

‡ Smith Woodward, *loc. cit.*, p. 103 (woodcuts). Since the reading of the paper, Mr P. E. Coombe has presented to the British Museum a tooth from the Chalk of Lewes (No. P. 5398) indistinguishable from *Acrodus levis*, thus adding this species to the Chalk list.

§ F. Dixon, 'Foss. Suss.' 1850, p. 364, Pl. xxx, Figs. 11, 12; Pl. xxxii, Fig. 9.

|| Smith Woodward, *loc. cit.*, p. 104.

however, considered it convenient to distinguish the fossil teeth under the name of *Oxyrhina*, from the circumstance that, though much like those of the true *Lamna*, they are almost invariably destitute of lateral denticles, and more compressed. The anterior teeth are long and narrow, while those behind gradually become broader, and then shorter and smaller. *O. Mantelli** is the common species of the Chalk, and is also met with occasionally in the Upper Greensand. The full-grown teeth are large and robust, and, though very rarely, show an occasional small lateral denticle. As proved by specimens in the British Museum, some of the hindmost and foremost teeth of this species were described and figured by Agassiz and Dixon under the name of *Lamna acuminata*.† Other very robust teeth, of extraordinary dimensions, are known as *O. crassidens*,‡ perhaps pertaining to a distinct species. There is a fine group in Mr. Willett's collection in the Brighton Museum.

Genus *Odontaspis*, Agassiz.

The teeth of *Odontaspis* differ from those of *Lamna* in being almost cylindrical in section, and they usually exhibit more or less of a sigmoidal curvature. Two small species occur in the Chalk—the one (*O. subulata*§) having the teeth quite smooth, the other (*O. raphiodon*||) possessing a delicate ornament of minute longitudinal ridges upon the hinder aspect of the crown. The first of these also occurs in the Gault and Greensand, and was originally founded upon a tooth from the Chalk Marl of Quedlinburg ("Quedlimbourg"), in Prussia. The type specimens of the second species, *O. raphiodon*, were obtained from the Upper Chalk of Lewes.

Genus *Otodus*, Agassiz.

Otodus is another genus founded by Agassiz upon teeth very similar to those of *Lamna*. It has no living representatives, and the teeth are recognized by (i) the much compressed form of the crown, (ii) the considerable size of the pair of lateral denticles, and (iii) the shortness of the root, which is only slightly branched.

* L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 280, Pl. xxxiii, Figs. 1-9.

† L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 292, Pl. xxxviii, Figs. 54-57. F. Dixon, 'Foss. Suss.,' Pl. xxx, Figs. 19, 26 (?), 34.

‡ F. Dixon, 'Foss. Suss.,' p. 367, Pl. xxxi, Fig. 13.

§ L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 296, Pl. xxxviii, Figs. 5-7.

|| L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 296, Pl. xxxviii, Figs. 11-16. F. Dixon, 'Foss. Suss.,' Pl. xxx, Fig. 32.

A single well-defined species, *O. appendiculatus*,* occurs both in the Chalk and the earlier Cretaceous deposits, and is very widely distributed, numerous examples being known both from England, the European Continent, and the United States. The teeth are especially stout, and the root much depressed; and there is considerable variation in size and shape, as shown by Agassiz's figures, and proved by the remains of nearly complete jaws in the British Museum. Larger and still more robust teeth from the English Chalk may be identified with the specimens from the Continental Greensand described by Agassiz as *O. crassus*;† and Mr. William Davies has determined one tooth from the Chalk of Rochester which agrees with Münster's *O. semiplicatus*,‡ of the Quedlinburg Chalk. The latter is large, and has the inferior margin of the outer face of the crown marked with small but strong vertical ridges.

Genus *Corax*, Agassiz.

Some small compressed triangular teeth, with delicately serrated margins, and short, slightly-branched root, are very suggestive, at first sight, of the occurrence in the Chalk of allies of the Blue Sharks (*Carcharias*) and Topes (*Galeus*). These teeth, however, when completely developed, are solid, whereas those of the genera of *Carchariidae* just mentioned have a central cavity§; and they were thus regarded by Agassiz as generically distinct, receiving the name of *Corax*, and being placed with the other solid-toothed sharks in the family of *Lamnidae*. The teeth vary much in form according to their original position in the jaw, some being almost symmetrical, but the majority with the apex of the crown directed backwards. The marginal serrations are mostly distinct, and always quite regular; but they are sometimes absent in the smaller teeth, which seem to have belonged to young individuals.|| Two, or possibly three, species occur in the English Chalk, two larger (*C. pristodontus*¶ and *C. maximus****) and a

* L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 270, Pl. xxxii, Figs. 1-25. F. Dixon, 'Foss. Suss.,' Pl. xxx, Fig. 25; Pl. xxxi, Fig. 17.

† L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 271, Pl. xxxvi, Figs. 29-31.

‡ Münster, ? MSS. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 272, Pl. xxxvi, Figs. 32, 33.

§ According to Agassiz, *op. cit.*

|| It is interesting to note that in the young of the living *Carcharias* the margins of the teeth are not serrated. A. Günther, 'Cat. Fishes Brit. Mus.,' Vol. viii, 1870, p. 357.

¶ L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 224, Pl. xxvi, Figs. 9-13.

*** F. Dixon, 'Foss. Suss.,' p. 366, Pl. xxx, Fig. 17.

smaller (*C. falcatus**). *C. pristodontus* is met with in the higher horizons, and was originally founded upon specimens from the well-known Maastricht Beds of Holland. The teeth are recognized by the great relative size of the root, and the bulging anterior margin of the crown. *C. falcatus* has a much narrower root, and the anterior margin of the crown only slightly curved; and, in small (? mostly young) examples there are also indistinctly marked broad lateral denticles.† The teeth of Dixon's *C. maximus*, from the Chalk of Lewes, are very similar in form to those of *C. falcatus*, and quite possibly belong to large individuals of this species.

Genus *Scylliodus*, Agassiz.

A fossil Dog-fish—one of the family of *Scylliidae*—appears to be indicated by some teeth and portions of the cartilaginous skeleton from the Lower Chalk of Burham and Dover. The largest of the type-specimens figured by Agassiz‡ shows the upper and lower jaws, with portions of labial cartilages and the ceratohyals, in addition to the greater part of the pectoral arch, and a long fragment of the vertebral column. The teeth are very small, of the same type as those of *Lamna*, but mostly having the lateral denticles larger, and the root shorter and depressed. Agassiz figures one tooth (*i.e.*, Fig. 3), but many are not so broad as this, and have the lateral denticles longer and more slender. As in all the *Scylliidae*, several rows of the teeth are simultaneously in use, and the entire dentition is much like that of the living *Scyllium*. There appear to be no dorsal spines, and the vertebral centra are short, being about twice as deep as long. The single recognized species is *Scylliodus antiquus*.

Another genus of Asterospondylic Selachians—the extinct *Strophodus*—has also been recorded from the Chalk§; but I have discovered that the type-specimen of the single described species, *S. asper*, Agass., is truly a fragment of a Crustacean somewhat similar to *Hoploparia*.

* L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 226, Pl. xxvi, Fig. 14, Pl. xxvii, Figs. 1-15. F. Dixon, 'Foss. Suss.,' Pl. xxx, Fig. 18.

† Some of these have been ascribed to *Sphyrna* by E. Hébert, "Tableau des Fossiles de la Craie de Meudon," 'Mem. Soc. géol. France' [2], Vol. v (1854), p. 354, Pl. xxvii, Fig. 9.

‡ Agassiz, *op. cit.*, Vol. iii, p. 377, Pl. xxxviii.

§ Agassiz, *op. cit.*, Vol. iii, p. 128b, Pl. xb, Figs. 1-3.

*Selachii Tectospondyli.*Genus *Squatina*, Aldrovandi.

The "Monk-fishes" or "Angel-fishes" have not yet been recorded from the English Chalk, but a nearly perfect example has been discovered in the Senonian of Westphalia,* another at Mount Lebanon, Syria,† and several detached teeth in Bohemia.‡ In the collection of the British Museum, however, I have met with one tooth from the Upper Chalk of Norwich, and another from Brighton; and our fellow-member, Mr. James Fox, has recently presented a third from Lewes. Another tooth is figured, without name, by Dixon.§ I have also detected remains of the head of *Squatina*, with some of the dermal tubercles, from the Lower Chalk of Brighton, in the collection of Mr. Henry Willett, F.G.S., in the Brighton Museum. The latter is a comparatively satisfactory specimen, and indicates a new species, *S. Cranei*.|| The teeth of the genus are compressed and conical, without distinct lateral denticles, and are easily recognized by a curious downward process of the crown extending over the root immediately beneath the great cone. The body is covered with exceedingly minute ridged or stellate tubercles, and towards the margin of the paired fins there are also larger round dermal plates with recurved spines. In *Squatina Cranei* the anterior lower teeth are remarkably slender, and the spinous dermal plates of unusual size.

Genus *Ptychodus*, Agassiz.

The teeth of *Ptychodus* are so well known to all collectors and readers of ordinary text-books, that any detailed description of their characters would be superfluous. Some account of their arrangement in the jaw may, however, be of interest, with a few remarks upon the probable systematic position of the fish to which they originally belonged.

* W. Von der Marck, "Fische der oberen Kreide Westfalens—Dritter Nachtrag," 'Palæontographica,' Vol. xxxi (1885), pp. 264-267, Pl. xxv, Figs. 1-5.

† *Squatina crassidens*, A. S. Woodward, shortly to be described in the British Museum Catalogue of Fossil Fishes.

‡ A. E. Reuss, 'Verstein. böhm. Kreideform.,' Part ii (1846), pp. 100, 101, Pl. xxi, Figs. 18-21.

§ F. Dixon, 'Foss. Suss.,' Pl. xxx, Fig. 35.

|| Smith Woodward, "On some remains of *Squatina Cranei*, sp. nov., etc., from the Chalk of Sussex," 'Quart. Journ. Geol. Soc.,' Vol. xlv (1888), p. 144, Pl. vii, Figs. 1-6.

By Mantell,* the well-known fossils in question were at first regarded as pertaining to a Teleostean fish, somewhat similar to the living Sea-hedgehogs (*Diodon*); but Agassiz† soon afterwards recognized their true Selachian nature, and gave them the name by which they are now designated. The author of the "Poissons Fossiles" thought that the teeth were arranged in the jaws like those of the living *Cestracion*, or Port Jackson Shark—the prehensile teeth in front, and those for crushing upon the ramus at each side. He also considered (*tom. cit.*, p. 56) that certain broad ribbed fossils, discovered in the same beds as the teeth, might reasonably be determined as the dorsal fin-spines of the fish, which was thus relegated to the *Cestraciontidae*. Owen‡ confirmed this determination by a study of the microscopical structure of the teeth, though at the same time both he and subsequent writers recognized the remarkable superficial resemblance of the fossils to the teeth of the living Ray, *Rhynchobatus*. Later researches by Prof. Cope§ among Cretaceous fossil fishes in North America, proved very conclusively that the supposed dorsal spines of *Ptychodus* really pertained to the pectoral fins of a family of Teleosteans (see *Protosphyraena*); and in 1885 the present writer|| was also able to announce that Agassiz had been misled by imperfect specimens in regard to the arrangement of the teeth, there being nothing in common with the *Cestraciontidae*, but striking points of resemblance to certain Rays. Still more recently further studies have made known¶ the complete dentition of at least one species—thanks, especially, to a fine fossil in Mr. Henry Willett's collection at Brighton—and it now appears that *Ptychodus* is either referable to a family of huge Devil-fishes (*Myliobatidae*) or to a closely allied group hitherto unrecognized.

* G. A. Mantell, 'Fossils of the South Downs,' 1822, p. 231.

† L. Agassiz, 'Poiss. Foss.,' Vol. iii (1839), p. 150.

‡ R. Owen, "On the Structure of Teeth," 'Brit. Assoc. Rep.,' 1838, Trans. Sect., p. 140; and 'Odontography,' pp. 57-59, Pls. xviii, xix.

§ E. D. Cope, 'Vert. Cret. Form. West,' 1875, pp. 244a-f.

|| Smith Woodward, "Chapters on Fossil Sharks and Rays—iv," 'Science Gossip,' Vol. xxi (1885), p. 109.

¶ Smith Woodward, "On the Dentition and Affinities of the Selachian Genus *Ptychodus*, Agassiz," 'Quart. Journ. Geol. Soc.,' Vol. xliii (1886), pp. 121-130, Pl. x.

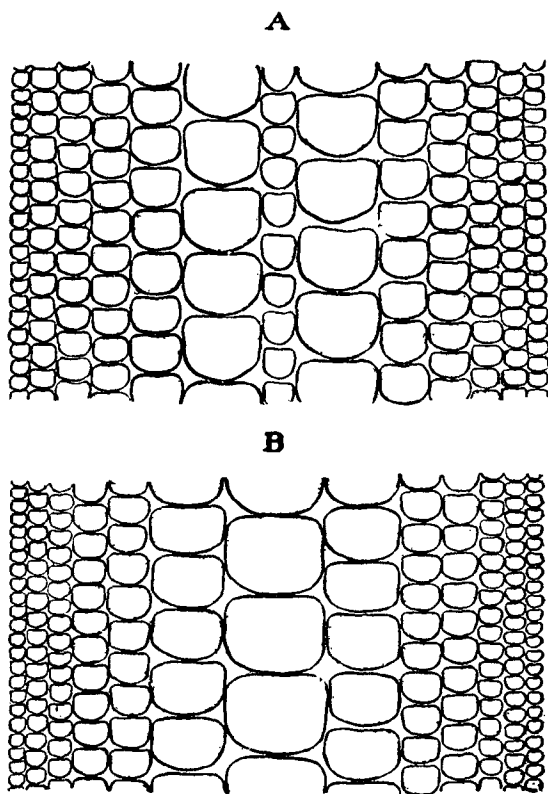


FIG. 1.—Diagram showing the arrangement of the teeth of *Ptychodus*. A. Upper jaw. B. Lower jaw.

The two halves of each jaw are placed in the same straight line, thus giving the aperture of the mouth the form of a straight transverse cleft, and the teeth are arranged in several parallel series, running directly antero-posteriorly. There is a median row in each jaw, and on either side of this there are symmetrically placed left and right series. In the upper jaw (Fig. 1, A), the median teeth are very small, and the largest are placed in the first lateral series, from which there is a gradual diminution in size outwards. In the lower jaw (Fig. 1, B), the median teeth form the largest row, fitting into the central groove of the opposing dentition, and on either side the teeth of the lateral series become successively smaller. Altogether there are thirteen of these parallel rows in the common *P. decurrens*.

From the uppermost Cretaceous rocks of Pernambuco, Brazil Prof. Cope* has described an interesting type of dentition, *Apocopodon*, which is apparently intermediate between *Ptychodus* and the living *Myliobatidæ*, and thus tends to confirm the present writer's determination already referred to. The median teeth "are shorter than in the typical forms assigned to *Myliobatis*," and "differ from the corresponding teeth of *Myliobatis* and *Zygobatis* in being exactly parallelogrammic in outline ; that is, the extremities are truncated instead of angulated as in those genera." "The lateral teeth display the usual angulation among themselves, though doubtless joined by a straight suture to the middle row." The crowns are more elevated than the roots, and separated from them by a constriction ; and the coronal surface is covered by a dense layer, marked with antero-posterior wrinkles.

Possibly of a similar type is the genus from Maastricht, represented by the detached teeth named *Rhombodus Binkhorsti*, Dames.†

It is also interesting to observe that some of the Eocene species of *Myliobatis* possess teeth remarkably similar in shape to those of *Ptychodus*. A form from the Phosphate Beds of North Carolina, described by Leidy as *Myliobatis jugosus*,‡ is especially noteworthy in this respect ; and, on the whole, therefore, it seems probable that the *Ptychodonts* will eventually prove to be primitive types of *Myliobatidæ*.

With regard to the species of *Ptychodus*, it is impossible to make any very definite statement at present. So far as can be determined, however, from the fragmentary materials available, it appears that not less than seven forms can be distinguished in the English Chalk. Those teeth in which the median transverse folds gradually pass on either side into the granulated marginal area, are referred to *P. decurrens*.§ Comparatively high-crowned teeth, with the granulated area delicately marked and radiately channelled,

* E. D. Cope, "A Contribution to the Vertebrate Palæontology of Brazil," 'Proc. Amer. Phil. Soc.,' Vol. xxiii (1886), p. 2.

† W. Dames, "Fischzähne aus der obersenenen Tuffkreide von Maastricht," 'Sitzungsb. Ges. Naturf. Freunde, Berlin,' 1881, pp. 1-3.

‡ J. Leidy, "Description of Vertebrate Remains chiefly from the Phosphate Beds of S. Carolina," 'Journ. Acad. Nat. Sci. Philad.' [2], Vol. viii (1877), p. 240, Pl. xxxi, Figs. 4, 5.

§ L. Agassiz, 'Poiss. Foss.,' Vol. iii, p. 154, Pl. xxv^b, Figs. 1, 2, 4, 6-8. F. Dixon, 'Foss. Suss.,' p. 362, Pl. xxx, Figs. 7, 8 ; xxxi, Fig. 1 ; xxxii, Fig. 5. Also *P. depressus*, Dixon, *op. cit.*, p. 363, Pl. xxxi, Fig. 9.

are termed *P. mammillaris*.* The teeth of *P. rugosus* are almost like those of *P. mammillaris*, but differ in the less defined character of the surface markings, and the irregularity of the transverse ridges.† The teeth of *P. Oweni*‡ have a gently rounded crown with very irregular widely-spread ridges. *P. polygyrus*§ is the name given to very variable teeth with the larger median ridges more or less curving round at the lateral extremities and sometimes forming loops. And some large teeth with the transverse folds of enormous relative size, not more than five or six in number, are known as *P. latissimus*.|| The English specimens commonly referred to the American *P. Mortoni*, Mantell,¶ are really the upper median teeth, of various other species.

Abraded teeth of *Ptychodus* are also occasionally met with, and Dixon has described two as “nascent teeth,”** while another flatter example forms the type of a so-called new genus and species *Aulodus Agassizi*. ††

The centra of the vertebral column of *Ptychodus* are well calcified, and their identity is proved by a specimen of *P. decurrens* in the British Museum (No. 39,436), in which they are intimately mingled with fragments of cartilage and teeth. An almost perfect vertebra from the Upper Chalk of Dorking has been described in mistake by Dr. Carl Hasse,‡‡ as pertaining to a Cretaceous species of *Selache*, named *S. Daviesii* (misspelt *Davisi*), in honour of Mr. William Davies, of the British Museum. In transverse section the vertebra shows four wedge-shaped hollows filled with matrix, in the form of a cross, and between these there are numerous closely-arranged concentric laminæ, apparently not connected by any radiating plates.

* Agassiz, ‘Poiss. Foss.’ Vol. iii, p. 167, Pl. xxvb, Figs. 12-20. Dixon, ‘Foss. Suss.’ p. 361, Pl. xxx, Fig. 6; xxxi, Fig. 4.

† Dixon, ‘Foss. Suss.’ p. 362, Pl. xxxi, Fig. 5.

‡ Dixon, ‘Foss. Suss.’ p. 364, Pl. xxxi, Fig. 2.

§ Agassiz, ‘Poiss. Foss.’ Vol. iii, p. 156, Pl. xxv, Figs. 4-11; Pl. xxvb, Figs. 21-23. Dixon, ‘Foss. Suss.’ p. 363, Pl. xxx, Fig. 9; xxxi, Fig. 10.

|| Agassiz, ‘Poiss. Foss.’ Vol. iii, p. 157, Pl. xxva, Figs. 1-6 (not Fig. 7, which represents a lower median tooth of *P. polygyrus*), Pl. xxvb, Figs. 24-62. *P. paucisulcatus*, Dixon, ‘Foss. Suss.’ p. 363, Pl. xxx, Fig. 3.

¶ *e.g.*, Dixon, ‘Foss. Suss.’ p. 364, Pl. xxxi, Figs. 6, 7.

** F. Dixon, ‘Foss. Suss.’ p. 364, Pl. xxx, Figs. 4, 5.

†† F. Dixon, ‘Foss. Suss.’ p. 366, Pl. xxxii, Fig. 6.

‡‡ C. Hasse, ‘Einige seltene paläontologische Funde,’ ‘Palæontographica,’ Vol. xxx (1884), p. 9, Pl. ii, Figs. 16, 17.

Order CHIMÆROIDEI.

The Chimæroid fishes are represented in the English Chalk by the teeth and dorsal fin-spines of three extinct genera, *Edaphodon*, *Ischyodus*, and *Elasmodectes* (= *Elasmognathus*, E. T. Newton). They are cartilaginous fishes with the vertebral column consisting merely of slender calcified rings, and commonly classed with the Sharks and Rays. From the latter, however, they differ fundamentally in having the upper jaw (palato-pterygo-quadrato cartilage) fused with the skull, and the gill-clefts are also covered with a fold of skin, so that it is convenient to regard them as a distinct order. The teeth are very remarkable, and easily recognized when once seen. Each consists of a mass of bony matter surrounding isolated patches, or "tritonal areas" of harder white dentine, covered with punctures (the openings of vascular canals). Beneath each functional grinding plate is a pillar of similar material, which grows gradually upwards to replace the topmost layer, as it is worn away by trituration. One of the teeth occupies each half of the lower jaw, meeting its fellow at the symphysis in front; it is of triangular shape, laterally compressed, with the anterior angle produced more or less into a beak, and the "tritons" are placed either along the cutting edge, or both in this position and upon the inner side. In the upper jaw there are two teeth on each side meeting in the middle line, and these correspond to the so-called palatine and vomerine teeth of the Dipnoan *Ceratodus*. The hinder pair are the largest, triangular in shape, and readily distinguished from the mandibular teeth in the commonest Chalk genera, by the fact of their not being laterally compressed, but having a flat, grinding surface with tritons, and meeting one another in the median line throughout their entire length. The fore-pair of median teeth are short, triangular, laterally compressed, and curved to meet each other in front, producing a kind of beak, with tritons only upon the cutting edge. Sometimes these teeth are spoken of respectively as mandibles, maxillæ, and premaxillæ, the tritonal areas being then termed teeth; but, though convenient, this nomenclature can scarcely be justified by the obvious homologies of the parts.

The spine in front of the dorsal fin, in most Chimæroids, is long, slender, laterally compressed, and marked on the sides with coarse longitudinal striæ. There are two rows of small, recurved denticles

on the hinder border, and the lower extremity is articulated with a large cartilage. Such detached fossil spines have been described by Agassiz from several formations under the name of *Leptacanthus*.

Genus *Edaphodon*, Buckland.

To the genus *Edaphodon* may be referred most of the Chimæroid fossils of the Chalk; and for detailed descriptions and figures both of these and other known forms, reference may be made to Mr. E. T. Newton's exhaustive Memoir on "The Chimæroid Fishes of the British Cretaceous Rocks," published by the Geological Survey in 1878. The mandibular tooth is recognized by the great width of the flat "symphysial" surface in front, by which it unites with its fellow of the opposite side, and by the absence of any outer bony thickening of the upper margin. There is one beak-tritor, and posteriorly, on the inner side, are two small tritors just beneath the upper margin, with a single larger one, sometimes longitudinally divided, below. The hinder upper tooth shows two inner tritors and one outer; and the anterior upper tooth is not readily distinguished from that of *Ischyodus*, though perhaps less robust. Seven Cretaceous species are recognized by Mr. Newton, five of these occurring in the Chalk itself. Of *E. Sedgwickii*, first founded upon a mandibular tooth from the Cambridge Greensand, the complete dentition has been found associated in the Chalk of Lewes. *E. Agassizii* occurs in the Chalk Marl and Lower Chalk, and one specimen in the British Museum shows the dorsal spine in association with the mandibular teeth. *E. Mantelli* ranges throughout the Upper and Lower Chalk and the Chalk Marl. *E. gigas* appears to be obtained from the Upper Chalk, and *E. crassus* from the Lower.

Genus *Ischyodus*, Egerton.

The teeth of *Ischyodus* are usually distinguished at once by a curious bony layer upon the outer aspect, that of the mandibular tooth forming a well-marked thickening of the upper border. The lower tooth also differs from that of *Edaphodon* in being ordinarily more slender, and in having the "symphysial surface" narrow, with a longitudinal ridge and groove. In the hinder upper tooth there are four tritors, instead of three, as in *Edaphodon*, a median one being placed between the inner and the outer. A variety of the common Gault species, *Ischyodus brevirostris*, is believed to

occur in the Lower Chalk ; and Mr. Newton founds a new species, *I. incisus*, upon a small, thin mandibular tooth from the same horizon.

Genus *Elasmodectes* (*Elasmognathus*, Newton).

A small Chimæroid mandibular tooth from the Lower Chalk of Southeram, Sussex, preserved in Mr. Willett's collection, is remarkable from the circumstance that it is adapted for cutting rather than crushing, like the mandibular tooth of the living *Chimæra*. As this type is evidently generically distinct, it has been described by Mr. E. T. Newton under the name of *Elasmognathus*,* in reference to the thin plate-like form of the tooth ; and the single recognized species is known as *E. Willetti*. The inner side of each dental plate is marked by parallel lines of growth, giving it a wavy appearance, and there are no downwardly-extending broad tritoral surfaces, like those of *Edaphodon* and *Ischyodus*. The outer side shows no thickening of the upper border, and this is wavy, exhibiting three peaks, the first at the symphysis, joining with its fellow of the opposite side to form the anterior beak. The fossil appears to be extremely rare, having only been met with in the Lower Chalk of Southeram, Sussex, and Burham, Kent. The upper teeth still remain undiscovered.

Order GANOIDEI.

The Ganoid fishes of the Chalk, so far as recognizable, are few. It is, however, impossible to determine how many of the genera, commonly placed under the physostomous Teleosteans, might fall under this denomination, if only we were acquainted with the characters of their soft parts. The Ganoids differ from the Teleostei in not having the optic nerves decussating, and in possessing a spiral valve in the intestine, and a contractile conus arteriosus in connection with the heart. The later members of the order cannot be definitely separated from the more primitive Teleosteans by skeletal characters alone ; and so many intermediate conditions in regard to the soft parts have also been discovered among living fishes within recent years, that the convenience of retaining this long-adopted division becomes questionable. Prof.

* As pointed out to me by Mr. Lydekker, this generic name was pre-occupied, having been employed by Dr. J. E. Gray, in 1867, for a Tapir. With little change of significance, the name of *Elasmodectes* (blade-biter) may be substituted.

Cope* has proposed a rearrangement especially worthy of consideration.

Crossopterygian (Fringe-finned) Ganoids.

Genus *Macropoma*, Agassiz.

A single representative of the Fringe-finned Ganoids occurs in the Chalk—the genus *Macropoma*, referable to the ancient, and now extinct, family of *Cœlacanthidæ*, founded by Agassiz† and amended by Huxley.‡ Like the earlier genera of the same family, *Cœlacanthus*, *Holophagus*, &c., it is a robust fish, with large head, two short dorsal fins, one anal, and a remarkable, large caudal fin, supported by interspinous bones both above and below; it also probably possessed a small supplementary caudal, but this has not yet been discovered. The roof of the skull is sharply bent above the orbit, the front portion being thus very steep, and the constituent bones are externally pitted; the outer jaw-bones and the opercular bones are ornamented with shining tubercles, and there is a pair of similarly marked gular plates between the rami of the mandible, replacing branchiostegal rays. The teeth are small, curved, and conical, most powerful in front, and those of the upper jaw are fixed at least upon the maxillæ, palatines, and (?) vomers. The notochord must have been persistent, there being no traces of vertebral centra in the fossils; and there are no ribs. A great ossified air-bladder, first recognized by Mantell,§ and mistaken by Agassiz for the stomach, is generally seen in the abdominal cavity of the fish. The scales are thin and cycloid, considerably overlapping, and the exposed portion is of rhombic shape, ornamented with “elongated splashes and dots of enamel.” The fin-rays of the dorsal, anal, and caudal fins are neither jointed nor branching, and each is provided with a double anterior series of sharp spinelets, having the points all directed towards the distal end of the ray.

* E. D. Cope, “Observations on the Systematic Relations of the Fishes,” ‘Proc. Amer. Assoc. Adv. Sci.’ Vol. xx (1871), pp. 317-343. See also ‘Proc. Amer. Phil. Soc.’ Vol. xvii (1878), p. 41, and *ibid.*, Vol. xxi (1884), pp. 577-579.

† L. Agassiz, ‘Poiss. Foss.’ Vol. ii, Pt. ii, p. 168.

‡ T. H. Huxley, “Illustrations of the Structure of the Crossopterygian Ganoids—Figs. Brit. Org. Remains,” Dec. xii (‘Mem. Geol. Sur.’), 1866.

§ G. A. Mantell, ‘Foss. South Downs,’ 1822, p. 239. The structure of this air-bladder has been described by W. C. Williamson, “On the Microscopic Structure of the Scales and Dermal Teeth of some Ganoid and Placoid Fishes,” ‘Phil. Trans.’ 1849, p. 463, Pl. xliii. Figs. 29, 30.

Only a single species, *M. Mantelli*,* is known from the English Chalk, but Reuss† and Fritsch‡ have determined others from Bohemia. Prof. Huxley's *M. substriolatum*, from the Kimmeridge Clay of Cottenham, is believed by Zittel§ and Reis to be generically distinct, and referable to *Coccoderma*, Quenstedt; while the so-called *M. Egertoni*, Agass.,|| from the Gault of Speeton, is really not referable to the *Cœlacanth* family.

The coprolites of *Macropoma* show the impressions of the spiral valve of the intestine, and were originally regarded as fossil firm-cones.¶

Actinopteran (Ray-finned) Ganoids.

Genus *Lophiostomus*, Egerton.

This is a ganoid fish of uncertain position, with a thick depressed head and body, enormous mouth, and an impenetrable armour of rhomboidal enamelled scales. A single species only has been described—*L. Dixoni*, Egerton,** from the Chalk of Alfriston, Sussex; and the type specimen, which shows the head, portions of pectoral and pelvic fins, and a few scales, is preserved in the British Museum. The head bones and the rays of the fins are ornamented with irregular tubercles of ganoine; and the margin of the jaw is provided, above and below, with a "single series of long, sharp, conical teeth, very regular in size, incurved at the points, and fluted on the surface." Smaller teeth of a similar type are also found in an inner row parallel to the outer, those of the upper jaw being probably situated upon the vomers and palatines. The scales are rhomboidal and covered with a thick layer of shining ganoine, which is irregularly pitted, and they may be readily

* L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, pp. 174-177, Pl. lxxv-a-d. T. H. Huxley, *op. cit.*, pp. 27-39, Pls. vii, viii. This species being originally named *Amia? levesiensis*, by Mantell (*op. cit.*, p. 239), it ought strictly to be termed *Macropoma levesiensis*; but in memory of Dr. Mantell, it seems preferable to adopt the widely accepted name.

† A. E. Reuss, "Neue Fischreste aus dem böhmischen Pläner," 'Denkschr. math.-naturw. Cl. k. Akad. Wiss. Wien,' Vol. xiii (1857), pp. 33-39, Pls. i, ii.

‡ A. Fritsch, 'Reptilien und Fische der böhmischen Kreideformation,' 1878, pp. 26-31, Pl. iii, Pl. iv, Figs. 2-7.

§ K. A. Zittel, 'Handb. Palæont.,' Vol. iii (1887), p. 176.

|| Described by Egerton, "Figs. and Descr. Brit. Org. Remains," Dec. ix ('Mem. Geol. Surv.,' 1857), Pl. x.

¶ See J. Parkinson, 'Organic Remains of a Former World,' Vol. i (1820), p. 447, Pl. vi, Figs. xv, xvii.

** Sir P. Egerton, "Figs. and Descriptions of British Organic Remains," Dec. vi ('Mem. Geol. Surv.,' 1852), Pls. x, x.*

recognized by the comb-like serrated posterior margin ; they have been met with in the Chalk of several English localities.

Genus non det.

Lophiostomus is not the only rhombic-scaled ganoid of which the English Chalk yields evidence. Agassiz* has already recorded (not described) some thick enamelled scales, slightly punctated, with apparently smooth posterior border, under the name of *Lepidotus punctatus* ; though a specimen in the British Museum (No. P. 4705) shows that this generic determination is incorrect, the scales of the ventral aspect of the fish being much more elongated than those of the flank, as in the Jurassic *Eugnathus*. Some of these scales, from the collection of Mr. S. J. Hawkins, F.G.S., are shown in Pl. I, Fig. 2, and it seems advisable at present to leave them generically undetermined.

Genus *Neorhombolepis*, A. S. Woodw.

Another fossil in the British Museum (No. 43,077) indicates a third genus of rhombic-scaled ganoids in the Chalk. It is shown, of the natural size, in Pl. I, Fig. 1.

This specimen, though too imperfect to allow of precise generic diagnosis, belongs to an interesting novel type, and, as a matter of convenience, I propose to adopt the usual palæontological expedient of applying to it a distinct name—that of *Neorhombolepis excelsus*—until the genus and species can be scientifically defined. The fossil was obtained from the Lower Chalk of Halling, Kent. It shows the opercular bones, postclaviculars, the right pectoral fin, numerous rows of ventral scales, and a portion of the vertebral column. The operculum is almost quadrate, and the suboperculum is relatively large, having about two-thirds the vertical extent of that bone. The postclavicular scales are four in number, and very similar to those of *Lepidotus*, *Dapedius*, and their allies ; and they are externally ornamented with fine rugose markings, as also, probably, would be the opercular elements if their outer surface were well preserved. The pectoral fin consists of thirteen powerful

* L. Agassiz, 'Poiss. Foss.,' Vol. ii., Pt. i, p. 306. A portion of a fish named *Lepidotus striatus* is also described and figured from the Chalk of Normandy, *tom. cit.*, p. 268, Pl. xxxiva, Fig. 4. H. E. Sauvage has since referred other detached scales, from the French Chalk, to *Lepidotus* ('Recherches sur les Poissons Fossiles du Terrain Crétacé de la Sarthe,' "Bibl. l'École Hautes Etudes," Vol. v, No. 9 (1872), pp. 4-6, Figs. 20-24).

rays, the first being especially robust; and all are undivided for the greater portion of their length, though closely articulated distally. The scales of the ventral aspect are very much elongated, being often nearly three times as long as deep, but those of the upper part of the flanks might possibly be deeper, as in other genera with a similar ventral squamation. These scales are enamelled and quite smooth, and some have posterior serrations; but they are not united by peg-and-socket joints. The vertebral column differs from that of all other genera with which the external characters of the fish would suggest comparison, in being completely ossified; and the vertebral centra are biconcave and relatively short.

The operculum of the specimen just described measures about 25 millim. vertically, and 25 millim. anteroposteriorly; the unjointed portion of the first ray of the pectoral fin is 40 millim. in length; an anterior ventral scale measures 4 millim. by 1.5 millim.; and each vertebral centrum has a depth of about 8 millim. and a length of 4.5 millim.

Genus *Belonostomus*, Agassiz.

This is a long-bodied fish, with strong enamelled ganoid scales, and is typically a Jurassic genus, though rarely represented by a single species, *B. cinctus*, Agass.*—and perhaps by a second, *B. attenuatus*, Dixon†—in the English Chalk. The scales of the middle of the flank are much vertically elongated, while those placed dorsally and ventrally are relatively short; all being smooth and destitute of posterior serrations. The snout is enormously elongated, and the lower jaw is almost of equal length. The latter is the most interesting part of the fish hitherto discovered, and I have lately been able to elucidate (*loc. cit.*) some of its characters by an examination of two of Mr. Willett's fine fossils from Brighton. Its great length is not due to the elongation of the halves of the jaw proper, but to the presence of an unpaired element in front (the "pre-symphysial bone") which has an extent equal to that of the whole of the ordinary mandibular bones themselves. This curious bone tapers in front and is provided with a median row of very large, hollow, conical teeth, at distant intervals, flanked on either side by very

* L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, p. 142, Pl. lxxvii, Figs. 10-13. F. Dixon, 'Foss. Suss.,' p. 367, Pl. xxxv, Figs. 3, 3.* Smith Woodward, "On a Mandible of *Belonostomus cinctus* from the Chalk of Sussex," 'Quart. Journ. Geol. Soc.,' Vol. xlv (1888), p. 145, Pl. vii, Figs. 7-13.

† F. Dixon, 'Foss. Suss.,' p. 368, Pl. xxxv, Figs. 4, 4.*

minute conical teeth. The rami of the jaw behind are provided with clustered, mammillated, crushing teeth, perhaps fixed upon the "splenial" bone. The latter have not previously been discovered, and the tooth-bearing fragments described by Agassiz are pieces of the presymphysial bone.

The latter bone is also present and dentigerous in the closely allied genus *Aspidorhynchus*, though here it is comparatively small. Its true characters in the Jurassic *Belonostomus* were first pointed out by Otto Reis.*

Genus *Prionolepis*, Egerton.

Some naturally associated ganoid scales from the Chalk of Burwell, near Newmarket, were figured in Dixon's 'Foss. Suss.' (Pl. xxxii*, Fig. 3), and briefly described by Sir Philip Egerton (*op. cit.*, p. 368), under the name of *Prionolepis angustus*; but nothing more has subsequently been discovered in regard to the essential characters of the fish. Sir Philip Egerton compared it with the long-bodied *Aspidorhynchus*, and it is perhaps most nearly allied to the family comprising the latter. The scales of the side of the trunk are much elongated vertically, being sometimes six times as deep as broad; and these are pierced at a distance of about one-third of the total depth from the upper end by the canal of the "lateral line." Above this, which produces a small transverse ridge, the scale is bent obliquely forwards, and below it curves still more gradually backwards, terminating in a somewhat rounded lower extremity. The posterior border, both of this scale and of the much shorter ones, which are placed dorsally and ventrally, has a comb-like appearance, being strongly denticulated; and the remainder of the external surface of the scale is either smooth or ornamented with very fine vermiculations.

The type specimen is now preserved in the British Museum, and there are also less perfect examples from the Lower Chalk of Dover, and the Upper Chalk of Dorking, Surrey, and Swaffham, Norfolk.

(?) Genus *Caturus*, Agassiz.

A fragment of jaw from the Chalk of Kent was referred by Agassiz† to the well-known Upper Jurassic genus *Caturus*, but no

* O. Reis, "Ueber *Belonostomus*, *Aspidorhynchus*, und ihre Beziehungen zum lebenden *Lepidosteus*," Sitzungsab. math.-phys. Cl. k. bay. Akad. Wiss. München, 1887, p. 169, Pl. i, Fig. 4.

† Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, p. 118, Pl. lxvii, Fig. 9.

subsequent discoveries have tended to confirm this determination, which is thus extremely doubtful. The fossil shows a series of widely spaced laterally compressed teeth fixed in sockets, and almost of uniform size, and it is not improbably referable to an unknown Teleostean. It bears the specific name of *similis*.

Genus *Cælodus*, Heckel.

Though the specimens are too imperfect to allow of certain determination, the majority of the known Pycnodont remains from the Chalk seem to pertain to *Cælodus** as already pointed out by Zittel.† In this genus the unworn teeth are hollowed in the middle of the summit of the crown (as denoted by the name), and the more elongated examples are also raised at either extremity. Each half of the lower jaw is provided with three series, the innermost being much the largest; and the teeth both of this and the second row are greatly transversely elongated, while in the outermost series they are small and round. In the upper jaw the median teeth are oval and transversely elongated to a slight extent; and these are flanked on either side by two rows of smaller oval teeth, the long axes placed in an antero-posterior direction.

The finest Pycnodont fossils hitherto described from the English Chalk are those from Houghton, Sussex, made known by Dixon,‡ and referred to Agassiz's *Gyrodus angustus* (now to be termed *Cælodus angustus*). One large specimen shows both mandibular rami, with the dentition, and some well-preserved scales, with the interspinous bones of the anal fin; and in another is preserved a portion of the axial skeleton with neural spines and ribs. The scales cover the anterior half of the trunk, having the usual form, and they are comparatively thick, with a pitted ornamentation. The ventral comb-like ridge-scales in the first specimen are erroneously described by Dixon as pertaining to "the nape of the neck." The lower dentition is not precisely of the ordinary *Cælodus*-type, nor yet quite like *Gyrodus*; there being one principal row of laterally elongated teeth, each with a median longitudinal depression soon obliterated by wear, and, on either side of this, small elongate teeth, with a deeper median hollow, irregularly arranged in series. Flanking these again are a number of very

* J. J. Heckel, 'Beiträge zur Kenntniss der fossilen Fische Oesterreichs,' Pt. i, 1849, p. 202, Pl. i, Fig. 6.

† K. A. Zittel, 'Handb. Palæont.,' Vol. iii, 1887, p. 245.

‡ F. Dixon, 'Foss. Suss.,' p. 370, Pl. xxx, Fig. 14; Pl. xxxiii, Fig. 1.

small teeth almost round and pitted at the summit. *Cœlodus cretaceus*, referred to *Pycnodus* by Agassiz,* is founded upon the mandibular dentition in the British Museum from the Lower Chalk of Halling, Kent. *Cœlodus parallelus*, referred by Dixon† to *Pycnodus*, is somewhat similar, but having the lower teeth more laterally elongated.

Acrotemnus fuba, Agassiz,‡ may also probably be placed here, and is very imperfectly defined, being only known from an unique fossil in the British Museum displaying a few detached teeth. *Phacodus punctatus*, Dixon,§ must further be dismissed as founded upon six much abraded teeth, in natural association, which are quite indeterminable.

Genus *Gyrodon*, Agassiz.

The detached vomerine dentition of a species of *Gyrodon* (*G. cretaceus*) from the Chalk of Lewes was described by Agassiz,|| and another example was subsequently figured by Dixon.¶ The crowns of the teeth are round or oval, comparatively high, coarsely rugose, and mostly hollowed at the summit. Between the large median series and the pair of lateral rows there are numerous teeth of smaller sizes placed irregularly. The lower dentition is still unknown, and, upon present evidence, Dixon's *G. conicus*** must be regarded as founded upon unworn teeth of this species.

(?) Genus *Microdon*, Agassiz.

Though recorded by Dixon,†† the genus *Microdon* is not certainly represented in the Chalk. I have already shown that "*Microdon nuchalis*" is truly a Teleostean fish,‡‡ and the fragment of the anterior portion of a Pycnodont described as *M. occipitalis* does not appear to be generically determinable.

Order TELEOSTEI.

Detached scales and teeth of Bony Fishes, or Teleostei, are abundant in the Chalk, and the accumulated discoveries of many years have also furnished the palæontologist with numerous

* L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, p. 198, Pl. lxxiia, Fig. 60.

† F. Dixon, 'Foss. Suss.,' p. 369, Pl. xxxiii, Fig. 3.

‡ L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, p. 203, Pl. lxvia, Figs. 16-18.

§ F. Dixon, 'Foss. Suss.,' p. 371, Pl. xxx, Fig. 16.

|| L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, p. 233, Pl. lxixa, Fig. 13.

¶ F. Dixon, 'Foss. Suss.,' p. 370, Pl. xxx, Fig. 15.

** F. Dixon, 'Foss. Suss.,' p. 370, Pl. xxxii, Fig. 8.

†† F. Dixon, 'Foss. Suss.,' p. 369, Pl. xxxii, Fig. 7; Pl. xxxii*, Fig. 2.

‡‡ See p. 326, *infra*.

tolerably perfect individuals by which the precise characters of several genera and species can now be determined. The majority of the forms seem to belong to the more primitive or *physostomous* division of the order, in which the air-bladder is connected with the gullet throughout life, and may perhaps in some cases have as much connection with respiratory functions as it is said to possess in the living Ganoids, *Amia* and *Lepidosteus*. Few of the Cretaceous fossils, however, can be definitely placed in still existing families. The Herrings and Salmon-tribe are apparently represented, but there are other types quite unknown in present seas. Of higher fishes—the *physoclysti*, or those in which the air-bladder of the adult is not connected by a duct with the alimentary tract—the English Chalk yields several types, though mostly referable to the less specialized groups. The grey mullets (*Mugilidæ*), with abdominal pelvic fins, seem to have representatives, and so also the Berycoid fishes, in which the pelvic fins are placed far forwards (being “thoracic”), but yet retain as many as seven or eight soft rays in addition to the spine. The majority of the spiny physoclostous fishes at the present day have the pelvic fins reduced to five soft rays at the most.

Physostomous Teleosteans.

These are generally characterized by the margin of the upper jaw being formed both by the maxilla and premaxilla, and by the absence of spinous rays in the pelvic pair of fins, which have an abdominal situation. Some of the Chalk fossils, however, referred to this division, are exceptional in possessing pelvic fin-spines, and certain other unusual features in the skull, and much yet remains to be learned as to their true systematic relationships.

These Cretaceous fishes, indeed, are not, as yet, very satisfactorily divided into families, though Prof. E. D. Cope has made valuable contributions to the subject. So far as I have had the opportunity of studying the specimens they seem to fall under at least five or six groups as follows:—

I. Laterally-compressed fishes with large and powerful maxillæ and premaxillæ, bearing teeth, the dentary being the only tooth-bearing bone of the lower jaw, provided with a single series, the palatine and ectopterygoid toothless. The teeth are placed in complete sockets. Vertebrae, except near the head, deeply two-grooved on each side in addition to possessing pits for insertion of

neural and hæmal arches. Ex. : *Portheus*, *Ichthyodectes*, *Daptinus*, *Saurocephalus*. (Forming the family *Saurodontidæ* of Cope.)

II. Fishes somewhat less laterally compressed, provided with scales or bony scutes, or both, and having the premaxillæ and maxillæ large, bearing powerful teeth in one or more series. The dentary bone of the lower jaw similarly dentigerous. The teeth not implanted in complete sockets, but anchylosed to the jaw-bones. Abdominal vertebræ, at least, without deep lateral pits, but longitudinally striated. Ex. : *Pachyrhizodus*, *Empo*, (?) *Stratodus*.

III. Fishes only moderately compressed from side to side, naked, or provided with scutes. Both maxilla and premaxilla long and slender, the former about half-excluded from the margin of the upper jaw by the latter; the maxillary and premaxillary teeth small. Palatines and ectopterygoids powerful, and bearing a single series of large teeth, upon expanded bases, anchylosed to the bone. Dentary bone of lower jaw with one series of large teeth, and one or more series of small teeth, similarly anchylosed. Vertebræ with two deep lateral impressions and pits for the neural and hæmal arches. Ex. : *Enchodus*, *Eurygnathus*,* *Eurypholis*, *Ischyrocephalus*, *Cimolichthys*, *Pomognathus*.

IV. Elongated fishes, with powerful dentition, and the trunk armed with several longitudinal series of bony scutes; not yet precisely defined and separated from groups II. and III. Ex. *Dercetis* (*Leptotrachelus*), *Pelargorhynchus*, *Plinthophorus*.

V. The *Protosphyrænidæ* (= *Erisichtheidæ*, Cope), with much elongated snout (ethmoid bone), and long maxilla loosely connected with the premaxilla; also believed to have an unusually complex mandible. Ex. : *Protosphyræna*.

VI. Clupeoids and Salmonoids.

Genus *Portheus*, Cope.

Among the type-specimens of a so-called genus, *Hypsodon*, Agassiz unfortunately mingled the remains of two distinct genera. This circumstance was first recognized by Prof. Cope,† who eliminated the one form under the generic name of *Portheus*, and left the other for further investigation. A few years later, Mr. E. T.

* J. W. Davis, "Foss. Fishes Mt. Lebanon," "Trans. Roy. Dublin Soc." [2], Vol. iii, 1887, p. 601. The name *Eurygnathus* had previously been employed for a beetle (Wollaston, 'Insecta Mader.', 1853, p. 20).

† E. D. Cope, 'Vert. Cret. Form. West,' 1875, p. 189.

Newton* confirmed Prof. Cope's determination, describing certain of the English fossils as *Portheus Mantelli*,† and referring another‡ to an uncertain species of the same genus; while he corrected and supplemented Agassiz's description of the other specimens,§ which he considered might still retain the old name of *Hypsodon lewesiensis*, and be regarded as the types thereof. The latter I have since discovered to be identical with Dixon's *Pachyrhizodus*, and, as both Agassiz's original description and figure are quite misleading, it is thus convenient to expunge the ill-defined term, *Hypsodon*, entirely from the nomenclature of the group.

The teeth of *Portheus* are of unequal sizes, cylindrical or flattened, without cutting edges, and placed in a single row upon the margin of the jaw. The teeth upon the premaxilla, the anterior portion of the maxilla, and in front of the mandible, are much larger than the others. The cranial bones are not sculptured, and the entire skull is made known by Prof. Cope (*loc. cit.*) and Mr. E. T. Newton.¶ There is at least one powerful smooth spine in advance both of the pectoral and pelvic fins.

The large English species, *P. Mantelli*, is founded upon the specimens figured and described in Mantell's 'Foss. South Downs,' p. 241, Pl. xlii, as pertaining to an "Unknown Fish," and subsequently referred by Agassiz to *Hypsodon*. Another species is *P. Daviesii*,¶ founded upon a maxilla and associated vertebra from the Lower Chalk, probably of Maidstone; and there appears to be less certain evidence of still more.

Genus *Ichthyodectes*, Cope.

The known remains of *Ichthyodectes* are less perfect than those of the preceding genus, and the dentition appears to differ but little except in its uniformity. The teeth are nearly of equal size, and the genus was originally founded upon American fossils.** A portion of the mandible of one species (*I. minor*) from the Sussex

* E. Tully Newton, "On the Remains of *Hypsodon*, *Portheus*, and *Ichthyodectes*, from British Cretaceous Strata, with Descriptions of new Species," 'Quart. Journ. Geol. Soc.,' Vol. xxxiii (1877), pp. 505-510.

† *Unknown Fish*, Mantell, 'Foss. South Downs,' 1822, p. 241, Pl. xlii. *Hypsodon lewesiensis*, Agassiz, 'Poiss. Foss.,' Vol. v, Pl. xxv, Figs. 1, 2.

‡ *Hypsodon lewesiensis*, Agassiz, 'Poiss. Foss.,' Vol. v, Pl. xxv, Fig. 3.

§ *Hypsodon lewesiensis*, Agassiz, 'Poiss. Foss.,' Vol. v, p. 99, Pl. xxv, Figs. 1, 2, 4, Pl. xxv, Figs. 4, 5.

¶ *Portheus gaultinus*, Newton, *loc. cit.*, pp. 512-520, Pl. xxii, Figs. 1-12.

¶ E. Tully Newton, *loc. cit.*, p. 511, Pl. xxii, Fig. 13.

** E. D. Cope, "On the Saurodontidae," 'Proc. Amer. Phil. Soc.,' Vol. xi, (1871), p. 536. Also E. D. Cope, 'Vert. Cret. Form. West.,' 1875, p. 205.

Chalk was figured by Dixon under the name of *Hypsodon minor*.* and Mr. E. T. Newton has discovered another form in the Lower Chalk of Dorking, with more delicate obliquely-implanted teeth, appropriately named *I. elegans*.†

Genus *Daptinus*, Cope.

To this genus Mr. E. T. Newton has referred a remarkably perfect head, with the opercular apparatus and anterior vertebræ, from the Lower Chalk of Dover.‡ The specimen, which is preserved in the British Museum, is apparently intermediate between the American fossils placed by Cope in the genera *Daptinus* and *Ichthyodectes*, and is therefore appropriately named *D. intermedius*. The bones exhibit no superficial ornamentation, and the outlines of the more prominent elements are described in detail. The teeth are smooth, laterally compressed cones, with sharp edges; and they have long, hollow roots, sunk as usual in deep sockets, being replaced vertically. The mandible is relatively long and slender; the premaxilla is short and deep; and the maxilla is also comparatively short, being deepest in front, where it joins the premaxilla and appears to articulate with the palatine. The opercular bones are very large, and the operculum itself is roughly quadrilateral. The vertebræ are completely ossified, and there is an elongated lateral pit upon the centrum between the rib and the neural arch; the basal halves of the latter seem to have been lodged in a pair of deep depressions in the centrum, and so likewise the small ossicles supporting the ribs.

Genus *Tomognathus*, Dixon.

The skull and mandible are the only parts of *Tomognathus* at present known,§ and these have not yet been described in detail. The skull is considerably deeper than broad, with a large orbit; and the bones are not externally ornamented. The upper jaw is formed both by the maxilla and the premaxilla. The premaxilla is short and deep, with an upwardly directed process, and bears three or four very large teeth; the maxilla is long and slender, gradually becoming deeper behind, and the teeth are much smaller than those of the premaxilla, rapidly decreasing in size backwards. The

* F. Dixon, 'Foss. Suss.,' p. xiv, Pl. xxxii,* Fig. 9.

† E. Tully Newton, *loc. cit.*, p. 521, Pl. xxii, Fig. 15.

‡ E. T. Newton, "Description of a New Fish from the Lower Chalk of Dover," 'Quart. Journ. Geol. Soc.,' Vol. xxxiv (1878), pp. 439-446, Pl. xix.

§ F. Dixon, 'Foss. Suss.,' p. 376-7, Pl. xxx, Fig. 31, Pl. xxxv, Fig. 1.

mandible is long, and the anterior half is tooth-bearing and narrow, though soon becoming relatively very deep posteriorly, by a characteristic upward curve of the superior border; as in the upper jaw, the dentary teeth are much the largest in front, and inside these is a series of very small teeth, probably fixed upon the splenial bone. All the teeth are nearly cylindrical, pointed, enamelled in the distal half, and apparently ankylosed to the jaw, without sockets; and the enamelled portion of each of the larger ones is also longitudinally ridged and grooved. The typical species is *T. mordax*, Dixon; and *T. leiodus*, Dixon, is very doubtfully distinct.

Genus *Pachyrhizodus*, Dixon.

The teeth of this genus have so much resemblance to those of a reptile of the type of *Mosasaurus*, that they are often mistaken for such. One fossil, indeed, as already remarked (p. 280), forms the type of Owen's "*Mosasaurus*" *gracilis*; another fragment of the mandible, as already recognized by Mr. William Davies, in labelling the collection of the British Museum, has been described as the upper jaw of an unknown saurian, *Acrodontosaurus Gardneri*;* and the possibly reptilian character of other specimens was discussed by Mr. Toulmin Smith, so long ago as 1846.†

The teeth are round and conical, with more or less recurved tips, and possess a long, stout base, hollow, and ankylosed to the jaw, but partly enclosed in a socket, incomplete on all sides except the outer. The premaxilla ‡ is horizontally broadened, though not deep, and bears a single series of moderate-sized teeth upon its outer border, with two relatively large "tusks" within. The maxilla and dentary bone of the mandible are each armed with a single series of the teeth. The last-named bone is very deep, thick, and sometimes much curved transversely; it very rapidly tapers in front, bending inwards to meet its fellow of the opposite side in a small swollen symphysis. The skull is wide and depressed, and the bones are destitute of external ornamentation. The vertebræ are deeper than long, showing short, delicate, longitudinal rugæ on the sides. The scales (Pl. I, Fig. 8) are much

* J. Wood Mason, "On a new Acrodont Saurian from the Lower Chalk," 'Quart. Journ. Geol. Soc.,' Vol. xxv, 1869, pp. 442-4, Pl. xix.

† Toulmin Smith, "On the Discovery of the Remains of a very remarkable Reptile or Fish in the Chalk of Kent," Charlesworth's 'London Geol. Journ.,' 1846, pp. 21-2. This group of fossils is now in the British Museum, and belongs to *Pachyrhizodus Gardneri*.

‡ This is the bone shown in Dixon's 'Foss. Suss.,' Pl. xxxiv, Fig. 9.

overlapping, having the exposed portion marked with a few discontinuous radiating grooves (as shown by Brit. Mus., No. P. 1808).

The most important contribution to our knowledge of *Pachyrhizodus* is that by Prof. Cope,* published in 1875; but much remains to be learned in regard to the characters of the fins and the affinities of the fish. The small English fossils made known by Dixon (*op. cit.*) are named *P. basalis*, and if the larger specimens, like those included by Agassiz in "*Hypsodon lewesiensis*,"† are specifically distinct both from this and from the American forms, they must receive the name of *P. Gardneri*—the portion of mandible made known by Wood Mason as *Acrodontosaurus Gardneri* being the first fragment of the species recognizably described and figured, with a name. Owen's "*Mosasaurus gracilis*" probably represents a third species, to be known henceforth as *Pachyrhizodus gracilis*.

Genus *Stratodus*, Cope.

This genus was founded by Prof. Cope‡ upon the maxillæ, pre-maxillæ, and palatine bones of a fish from the Cretaceous Blue Limestone of Fort Wallace, U.S.A., remarkable on account of its singular dentition. The teeth are anchylosed to the jaw and placed in two or more series; they are hollow, more or less cylindrical in section, and have the base of great length, with a relatively small, sharp-edged pointed crown. In the fossils each tooth is thus almost white in colour for the greater part of its length, merely capped with a black tip. No similar specimens have hitherto been recorded from the English Chalk, but I have met with a few examples in the National Collection, which appear to differ only from Cope's *S. apicalis* in having the teeth less curved, with somewhat larger crowns. They may thus be known as *Stratodus anglicus*. One bone from Glynde, Sussex (No. 49,906), of which a portion of the dentition is shown in Pl. I, Fig. 3, is very similar in character and dimensions to the so-called palatine of the American species, though it has much the appearance of an external element. It is associated with indeterminable crushed bones, of which one large piece shows a slight ornament of irregular parallel rugæ. Another detached portion of bone (No. 49,780), shown in

* E. D. Cope, 'Vert. Cret. Form. West,' pp. 220-226, with plates.

† L. Agassiz, 'Poiss. Foss.,' Vol. v, p. 99, Pl. xxv, Figs. 1, 2, 4; Pl. xxv, Figs. 4, 5.

‡ E. D. Cope, 'Vert. Cret. Form. West,' 1875, pp. 226-7, Pl. xlix, Figs. 6-8.

Pl. I, Fig. 4, is shaped like the anterior part of the dentary of *Pachyrhizodus*, but agrees in size and characters with *Stratodus*, and shows the points of insertion of two rows of teeth, which have unfortunately been broken away; the external surface has a wrinkled appearance. The originally exposed surfaces of these and other similar fossils exhibit a curious greenish-grey dull appearance, by which they are readily recognizable.

Genus *Enchodus*, Agassiz.

Some fragmentary remains of a predaceous fish, with powerful dentition, not uncommon in the Chalk, were described by Agassiz under the generic name of *Enchodus*.* Prof. Cope† subsequently investigated the genus, but still only with imperfect materials; and more or less complete fishes of the same type, perhaps generically distinct, have also been discovered in the Cretaceous of Westphalia and Mount Lebanon.

The skull of *Enchodus* (Pl. I, fig. 5)‡ is of triangular form, with flattened roof, but not much depressed, and only the postero-lateral portions of the cranial roof are sculptured. The margin of the upper jaw is formed by a deep thin premaxilla (*pmx*) and a long slender maxilla (*mx*), the latter being placed partly behind the former; and upon this margin are arranged small teeth. The premaxilla is the bone shown in the lower right-hand corner of Fig. 1 upon Agassiz's Plate xxvc, *tom. cit.*, and its teeth are larger than those of the maxilla, and differ in being few and widely spaced.§ The palatine (Pl. I, fig. 6, *pal.*) and ectopterygoid (*id.*, *ectp.*) are strong bones, and bear a powerful dentition, not placed in sockets, but firmly ankylosed. The palatine is an especially robust element, and is provided with a single long terminal tooth; it is one of the most commonly discovered parts of the fish, and has been erroneously described hitherto as the premaxilla.|| The lower jaw (Pl. I, fig. 5, *d*) is moderately deep, and, like the oper-

* L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. i, p. 64.

† E. D. Cope, 'Vert. Cret. Form. West,' pp. 238-240.

‡ The following notes are based upon a skull of *Enchodus Faujasii* from Maastricht (Brit. Mus., No. 42,976), and two of *E. levisiensis* from Sussex (Brit. Mus., No. P. 5415, and Willett Coll., No. 65).

§ The supposed premaxilla of *Enchodus* described by H. E. Sauvage, 'Bull. Soc. géol. France' [3], Vol. xi (1883), appears to the present writer to be the anterior extremity of the dentary bone.

|| Except by H. B. Geinitz ("Das Elbthalgebirge in Sachsen," in 'Palæontogr.,' Vol. xx, Pt. ii, Pl. xli, Figs. 13, 14), who describes one specimen as the anterior extremity of the mandible.

cular bones, is externally ornamented with series of minute tuberculations ; it bears a row of large teeth, spaced at long irregular distances, and external to these is a closely-set series of small teeth. All the teeth of both jaws exhibit considerable lateral compression for the greater part of their length, and thus have one or two opposing sharp edges. The sides of the vertebræ are impressed with deep longitudinally-extended pits.

The single recognized species from the English Chalk was originally described as *Esox lewesiensis* by Mantell,* and must thus be known as *Enchodus lewesiensis*. It was, however, re-named by Agassiz *Enchodus halocyon*,† and the same naturalist described a second larger species, *E. Faujasii*, from the Upper Cretaceous of Maastricht, Holland. The latter has not yet been discovered elsewhere, unless some of the larger English fossils are correctly referable to it.

Genus *Cimolichthys*, Leidy.

In his great work Agassiz ‡ described and figured a fragment of bone bearing semi-barbed teeth from the Chalk of Lewes, which he considered to belong to a species of *Saurocephalus*, made known by Hays in the United States under the name of *Saurodon Leanus*.§ Dr. Leidy,|| however, subsequently pointed out that the English and American fossils were generically distinct, proposing the new name of *Cimolichthys lewesiensis* for the former ; and more recently Mr. E. T. Newton¶ has carefully studied the subject, extending Leidy's results, and showing that the semi-barbed teeth are fixed upon the palatine and pterygoid bones of an otherwise unknown fish. Similar teeth have also been described on the Continent as the dorsal fin-spines of a shark (*Spinax marginatus*, Reuss), and as possibly referable to the Teleostean *Anenchelium* (= *Lepidopus*).**

* G. A. Mantell, 'Foss. South Downs,' p. 237, Pl. xxxiii, Figs. 2-4; Pl. xli, Figs. 1, 2.

† L. Agassiz, 'Poiss. Foss.,' Vol. v. Pt. i, p. 64, Pl. xxvc, Figs. 1-16.

‡ L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. i, p. 102, Pl. xxvc, Figs. 30, 31.

§ J. Hays, "Description of a Fragment of the Head of a new Fossil Animal" (*Saurodon*), 'Trans. Amer. Phil. Soc.,' N.S., Vol. iii (1830), pp. 471-477, Pl. xvi.

|| J. Leidy, "Remarks on *Saurocephalus* and its Allies," 'Trans. Amer. Phil. Soc.,' Vol. xi (1857), p. 95.

¶ E. T. Newton, "Remarks on *Saurocephalus*, and on the Species which have been referred to that Genus," 'Quart. Journ. Geol. Soc.,' Vol. xxxiv (1878), pp. 789-792.

** References to these various determinations will be found in a recent paper by W. Dames, "Die Gattung *Saurodon*, Hays," 'Sitzungsb. Ges.

The undescribed specimens in the British Museum add considerably to our knowledge of the fish—especially a fine skull and mandible from the Chalk of Lewes (No. P. 5491). The skull is depressed, and the hinder lateral portions of the roof are ornamented with fine radiating, tuberculated ridges, resembling those of *Enchodus* and *Pomognathus*. The premaxillæ and maxillæ are long and slender, with very small teeth; but the palatines and ectopterygoids are strong and bear a series of powerful teeth, ankylosed directly to the bone, many being of the familiar semi-barbed shape. The dentary bone of the mandible* is thin, but so bent that it has a wide horizontal extent; there is a single row of large recurved teeth, slightly compressed, with sharp edges near the apex, and not barbed, placed at long and irregular intervals; outside there is a close series of much smaller but similar teeth; and on the extreme outer margin there is a very minute row. The remainder of the skeleton is still unknown.

The above description shows that the so-called "*Saurocephalus striatus*," Agass., cannot belong to this genus—a possibility suggested, with hesitation, both by Dr. Leidy (*loc. cit.*, p. 94) and by Mr. E. T. Newton (*loc. cit.*, p. 793).

Genus *Pomognathus*, Dixon.

The skull of *Pomognathus* is scarcely distinguishable, upon a superficial glance, from that of *Cimolichthys*, but there are some differences in the dentition. The palatine and ectopterygoid are armed with large sharply-pointed, laterally-compressed teeth, ankylosed to the bone, and not barbed; and these teeth are largest in the middle of the arcade thus formed, diminishing towards either extremity. The premaxilla and maxilla are long and slender, the latter half-overlapping the former. The premaxilla is provided with two or more rows of very minute teeth, and the hinder portion of the maxilla bears a series of large, widely-spaced, anteriorly-directed teeth, immediately above which is seen an ornamented jugal bone. The mandible is also shaped like that of *Cimolichthys*, but is externally ornamented with tuberculated ridges; there are numerous large recurved conical teeth, of irregular sizes, placed in several rows within, and similar

Naturf. Fr. Berlin, 1887, pp. 72-78. Prof. Dames has unfortunately overlooked the papers by Leidy and Newton quoted above, and has apparently not referred to Hays' original description; he thus erroneously supposes that the European detached teeth are identical with those of the American fossil.

* Figured by Dixon, 'Foss. Suss,' Pl. xxxii*, Fig. 10.

very minute teeth are clustered upon the margin. Dixon * figures the nearly complete fish, named *P. eupterygius*, in Mr. Willett's collection, but the details of structure are unfortunately not indicated.

As already detected by Mr. William Davies, while labelling the fossils in the British Museum, one of the skulls from Lewes assigned by Agassiz † to *Osmeroides lewesiensis*, truly belongs to *Pomognathus eupterygius*, and the upper dentition there shown is that of the ectopterygoid and palatine.

Genus *Dercetis*, Agassiz.

The fishes of this genus are much elongated, and readily recognized by the longitudinal series of arrowhead-shaped scutes arranged upon the entire length of the trunk. The jaws are armed with powerful recurved teeth, though it is not definitely determined upon which bones these are fixed. The vertebræ are long and constricted in the middle, and the base of the neural arch is always very broad. The fins of the single recognized English species, *D. elongatus*, ‡ are unknown.

One series of the dermal scutes is perforated by the canal of the "lateral line," and these dermal defences are often beautifully ornamented with minute spinelets, in addition to the usual median thorn-shaped prominence. Dr. G. J. Hinde has kindly submitted to me a perfect specimen obtained from a cavity in a flint nodule, which forms a most beautiful object for microscopical examination. It is shown from above, eight times the natural size, in Pl. I, fig. 7

Remarkable elongated fossils consisting of a conglomeration of scales and fin-rays have also been referred to *Dercetis*. Some were originally described by Mantell § under the name of *Muræna ? lewesiensis*; and two fragments were afterwards included by Agassiz || among the type-specimens of *Dercetis elongatus*. As already pointed out by Mr. William Davies, ¶ however, these fossils rarely show the *Dercetis* scutes, but exhibit the scales of

* F. Dixon, 'Foss. Suss,' p. 367, Pl. xxxv, Figs. 6, 7.

† L. Agassiz, 'Poiss. Foss.,' Vol. v, Pl. lxb, Figs. 3, 4.

‡ L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, p. 258, Pl. lxxvii, Figs. 1, 2, 5-8 (non Figs. 3, 4).

§ G. A. Mantell, 'Foss. South Downs,' 1822, p. 232, Pl. xxxiv, Fig. 10 ; Pl. xl, Fig. 2.

|| L. Agassiz, 'Poiss. Foss.,' Vol. ii, Pt. ii, Pl. lxxvii, Figs. 3, 4.

¶ W. Davies, "On some Fish Exuviae from the Chalk, generally referred to *Dercetis elongatus*, Ag.," 'Geol. Mag.' [2], Vol. vi (1879), pp. 145-148.

several genera of fishes confusedly mingled together, and they may thus be almost certainly regarded as the linings of worm-burrows. Similar fossils have been described by Dr. Anton Fritsch, from the Chalk of Bohemia, under the name of *Lepidenteron longissimum*.*

It may further be pointed out that Agassiz's description of the fins of *Dercetis* is in no respects confirmed by any of the English fossils I have had the opportunity of examining, and was probably founded upon the Westphalian specimen briefly noticed as "*Dercetis scutatus*, Münt. et Agass." If so, it seems almost certain that the latter is identical with the specimens of a distinct genus subsequently described by W. von der Marck † under the name of *Pelargorhynchus*. Upon present evidence the fossils from the English Chalk are indistinguishable from those named *Leptotrachelus*, W. von der Marck, from Westphalia and Mount Lebanon.‡

Genus *Plinthophorus*, Günther.

This genus is founded upon a nearly complete fish, wanting the head, from the Lower Chalk of Folkestone, and is evidently allied to *Dercetis*.§ The body is oblong, without scales, but is described as possessing a dorsal and ventral series of imbricate, arrow-head-shaped, long scutes on each side. Each scute has a low longitudinal median keel upon the external surface, and the broad, hinder, exposed portion is marked by a rugose ornament, and slight radiating ridges. The paired fins are well-developed, without spinous rays; and the pelvics, which are abdominal in situation, consist each of about ten rays. The dorsal fin is of small extent, opposite the pelvics; the anal is short, mid-way between the pelvics and the caudal, and the latter fin is forked. The vertebral column consists of about sixty well-ossified vertebrae, each constricted in the middle and marked by small longitudinal furrows. The single known species is *P. robustus*.

* A. Fritsch, 'Rept. u. Fische böhm. Kreideform,' p. 19.

† W. von der Marck, 'Ueber einige Wirbelthiere, &c., der Westfälischen Kreide,' 'Zeitschr. deutsch. geol. Ges.,' Vol. x (1858), p. 242; and "Fossile Fische, &c., aus dem Plattenkalk der jüngsten Kreide in Westphalen," 'Palæontographica,' Vol. xi (1863), p. 61, Pl. xi, Pl. xii, Fig. 3.

‡ See especially figures by J. W. Davis, "Foss. Fishes Mt. Lebanon," 'Trans. Roy. Dubl. Soc.' [2], Vol. iii (1887), Pl. xxxviii, Figs. 1-3.

§ A. Günther, "Description of a New Fossil Fish from the Lower Chalk," 'Geol. Mag.,' Vol. i (1864), pp. 114-118, Pl. vi.

Genus *Protosphyraena*, Leidy.

The detached teeth of this genus are among the commonest of Chalk fossils, and the history of the acquisition of our present knowledge of the fish to which they belong is lengthy and intricate. Messrs E. T. Newton* and William Davies† have both published critical summaries of the literature of the subject, and it will, therefore, be sufficient here merely to give a succinct account of the main points.

The teeth are laterally-compressed and lanciform, without marginal serrations, and when found in connection with the jaw are seen to be fixed in distinct sockets. They were first noticed in 1822 by Dr. Mantell,‡ who described one example as belonging to an unknown fish, and referred a second to an undetermined species of shark. Twenty-one years later Prof. Agassiz studied the fossils, and thought that they were most probably identical with certain teeth discovered by Dr. Harlan§ in the Cretaceous strata of North America, which had been described under the name of *Saurocephalus lanciformis*, and erroneously placed among the Reptilia. They were accordingly made known as such in the great work on the 'Poissons Fossiles';|| and the determination was subsequently adopted by Dixon,¶ in 1850, who figured more satisfactory specimens. At this time, moreover, an important addition to our knowledge of the species was rendered possible by a fine fossil in Sir Philip Egerton's collection, which showed that the fish had a remarkably elongate snout. Six years afterwards Prof. Leidy** carefully re-examined Dr. Harlan's original American specimens of *Saurocephalus*, and soon became convinced that Agassiz was mistaken in supposing that the English fossils were identical with these even generically. He thus proposed a new generic and specific name—*Protosphyraena ferox*—for the specimens figured

* E. T. Newton, "On *Saurocephalus*," 'Quart. Journ. Geol. Soc.,' Vol. xxxiv (1878), pp. 786-796.

† W. Davies, "On the Nomenclature of *Saurocephalus lanciformis* of the British Cretaceous Deposits; with Description of a New Species (*S. Woodwardii*)," 'Geol. Mag.' [2], Vol. v (1878), pp. 254-261, Pl. viii.

‡ G. A. Mantell, 'Foss. South Downs,' p. 227, Pl. xxxiii, Figs. 7-9.

§ R. Harlan, "On a New Fossil Genus of the Order Enaliosauri, Conyb.," 'Journ. Acad. Nat. Sci. Philad.,' Vol. iii (1824), pp. 331-337, Pl. xii, Figs. 1-5.

|| L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. i, p. 102, Pl. xxvc, Figs. 21-29.

¶ F. Dixon, 'Foss. Suss.,' p. 374, Pl. xxx, Fig. 21; Pl. xxxi, Fig. 12; Pl. xxxii,* Fig. 1; Pl. xxxiv, Fig. 11.

** J. Leidy, "Remarks on *Saurocephalus* and its Allies," 'Trans. Amer. Phil. Soc.,' Vol. xi (1860), pp. 91-95.

by Mantell, Agassiz, and Dixon; wrongly suggesting, however, that Sir Philip Egerton's fossil rostral bone truly belonged to a sword-fish, which might be appropriately termed *Xiphias Dixoni*. Between 1875 and 1877, remains similar to those of the English Chalk were actually discovered in America, and not only proved that Egerton and Dixon were right in deciding upon the reference of the long snout to *Protosphyræna*, but also added further important anatomical details. Prof. Cope, however, who described these fossils,* proposed the difficultly pronounceable name of *Erisichthe*, which happily becomes a synonym.

Only one species of *Protosphyræna* (*P. ferox*, Leidy) has hitherto been detected in the English Chalk, and but little is known as to the systematic position of the genus. The name was originally suggested by the form of the teeth, which are not very unlike those of the living *Sphyræna*; but it is now certain that the fossil form cannot be placed in immediate proximity to the latter. The structure of the lower jaw is described as being very complex.

With *Protosphyræna* I would also venture to associate the fragment of snout described by Agassiz† as *Tetrapterus minor*. The caudal vertebræ made known at the same time may also be provisionally placed here, for they are quite distinct from those of the living *Tetrapterus* (= *Histiophorus*).

The fins of *Protosphyræna* were originally described by Agassiz‡ as the dorsal fin-spines of the Selachian fish *Ptychodus*, and were first recognized as Teleostean by Prof. Cope,§ who referred them to a genus *Pelecopterus*, indicating a previously unknown order (*Actinochiri*) and family (*Pelecopteridæ*). Each of these fossils is "composed of parallel rods in close apposition. The anterior edge being oblique, the extremities of the rods terminate successively at the border, which is trenchant, constituting the offensive part of the spine. The edge is hardened and the adjacent parts of the spine thickened, and in some cases roughened by a deposit of a hard substance resembling enamel. It is either straight, or regularly undulate or serrate, with recurved, acute, tooth-like

* E. D. Cope, 'Vert. Cret. Form. West,' 1875, pp. 217-218. Also E. D. Cope, "On the Genus *Erisichthe*," 'Bull. Geol. Surv. Territ.,' Vol. iii (1877), pp. 821-823.

† L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. i, p. 91, Pl. lxa, Figs. 9, 10.

‡ L. Agassiz, 'Poiss. Foss.,' Vol. iii, pp. 56-59, Pl. xa, xb, Fig. 18.

§ E. D. Cope, 'Vertebrata Cret. Form. West,' 1875, pp. 244a-f.

processes. The smaller species exhibit the serrate character; the larger, the regular border" (Cope).*

Genus *Osmeroïdes*, Agassiz.

Much still remains to be discovered in regard to the characters and relationships of the various fossils referred by Agassiz to *Osmeroïdes*.† The genus was founded upon some fishes from the Westphalian Chalk, which appeared to possess an adipose dorsal fin, and were considered to be closely allied to the living Smelts (*Osmerus*), being distinguished mainly by their more depressed and rounded trunk, and the breadth of the pedicle of the tail. These specimens showed no traces of scales (though such have subsequently been discovered), and in associating with them an English Chalk fossil provided with robust scales, Agassiz expressed some doubts as to its generic identity. W. von der Marck afterwards‡ decided that the Westphalian fishes possessed no adipose dorsal fin, and were thus most probably *Clupeidæ*; and, in the case of these, he proposed to substitute the name of *Sardinioides* for *Osmeroïdes*, leaving the latter term to apply only to the English specimens. Whatever may be the result of future researches, it will be convenient here to retain the familiar name of *Osmeroïdes lewesiensis* for the fish of the Lewes Chalk.

The latter was originally described by Mantell§ as *Salmo lewesiensis*, and has been well figured both by Agassiz|| and in Mantell's own popular works. The skull is much depressed, with flattened roof, and the bones are ornamented with a marked rugosity. The teeth must have been minute and clustered upon the margin of the jaws. The dorsal fin is short, placed almost in the middle of the back, and the pelvic fins are small, and not quite opposite to the dorsal, being placed more posteriorly. All the fin-rays are very robust. The scales are cycloid and deeply overlapping, either without external ornament, or faintly rugose.

Under the name of *Osmeroïdes crassus*, Dixon¶ briefly notices a

* This amended paragraph has been added since the reading of the paper, from information kindly furnished by Prof. E. D. Cope and Mr. William Davies.

† L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. ii, p. 103.

‡ W. von der Marck, "Fossile Fische, etc., aus dem Plattenkalk der jüngsten Kreide in Westphalen," 'Palæontographica,' Vol. xi (1863), pp. 41-45.

§ G. A. Mantell, 'Foss. South Downs,' 1822, p. 235, Pl. xl, Fig. 1; Pl. xxxiii, Fig. 12; Pl. xxxiv, Figs. 1, 2.

|| L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. ii, pp. 105-107, Pl. lxb, Figs. 1, 2, 5-7, Pl. lxc. (Nom. Pl. lxb, Figs. 3, 4; see above, p. 318.)

¶ F. Dixon, 'Foss. Suss.,' p. 376.

fine head, with anterior portion of the trunk, from the Chalk of Southeram, in Mr. Willett's collection. So far as known, it seems to differ from *O. levesiensis* mainly in the characters of the dentition. The premaxilla is short and stout, with a single large conical tooth well within the mouth, and other smaller ones near the outer border. The maxilla is relatively long, with a series of small marginal teeth; and the dentition of the lower jaw is very powerful.

Some fishes from the Cretaceous of Mount Lebanon have also been described under the name of *Osmeroides* by Messrs. Pictet and Humbert* and J. W. Davis.†

Genus *Acrognathus*, Agassiz.

This is a small, very rare fish, with elongate, rounded body, and broad, depressed head, placed by Agassiz‡ among the *Salmonidæ*, and believed by Dr. Günther§ to be a deep-sea representative of that family. The orbits are enormous—a circumstance which suggested the name of *A. boops* for the only known species. The lower jaw is very deep, and the teeth exceedingly minute. The pelvic fins are abdominal, and the dorsal is placed immediately opposite to them. The anal fin is remote. The scales are large, smooth, without posterior crenulations, and deeply overlapping.

The type-specimen of *Acrognathus boops* was obtained by Dr. Mantell from the Upper Chalk of Lewes; and there is a second fragment in the British Museum, showing the mandible and some vertebræ, from Shalford, near Guildford, determined by Mr. William Davies.

Genus *Aulolepis*, Agassiz.

Aulolepis also seems likely to have been a deep-sea Salmonoid, as suggested by Agassiz and Günther (*op. cit.*). The body is rounded and the head correspondingly depressed. The teeth on the margin of the jaw are very small, and the maxilla is large, being dentigerous, and entering considerably into the formation of the upper jaw. The pelvic fins are apparently abdominal, though slightly advanced forwards; and one or two of the long anterior rays of the dorsal fin seem to be spinous. All the fins are powerful

* F. J. Pictet et A. Humbert, 'Nouvelles Recherches sur les Poissons fossiles du Mont Liban,' 1866, p. 77.

† J. W. Davis, "Foss. Fishes Mt. Lebanon," 'Trans. Roy. Dublin Soc.' [2], Vol. iii, 1887, pp. 557-567, Pls. xxxi, xxxii.

‡ Agassiz, *op. cit.*, Vol. v, Pt. ii, p. 108, Pl. lxa, Figs. 1-4.

§ A. Günther, 'Study of Fishes,' 1880, p. 631.

—the caudal especially so. The scales are very large, smooth, without posterior serrations, and deeply overlapping; those of the “lateral line” are more truncate posteriorly than the remainder, and each of the series bears a little “pipe” for the reception of the slime-canal with its sense-organs—a feature giving rise to the name of the genus (“pipe-scale”).

The single recognized species is *Aulolepis typus*,* founded upon one of Dr. Mantell’s fossils from Lewes. Two much more satisfactory specimens are now preserved in the British Museum, from the Lower Chalk of Burham, Kent, and the higher beds of Dorking, Surrey.

Elopine Clupeoid Fishes.

No remains of undoubted Clupeoids have hitherto been recorded from the English Chalk; but I have seen several specimens of undescribed allies of the primitive existing *Elops*, and one very large genus and species is indicated by fossils in the British and Woodwardian Museums. One Elopine Clupeoid from the Lowermost Chalk of Bohemia bears the name of *Elopopsis Heckeli*.†

Physoclistous Teleosteans.

In this group of Teleostean fishes the air-bladder, when present, is not connected by a duct with the alimentary canal in the adult. Except in the Flat-fishes and Cod-fishes (*Anacanthini*), some of the rays of the dorsal, anal, and pelvic fins are always converted into spines. The tooth-bearing margin of the upper jaw is most commonly formed entirely by the pre-maxilla to the exclusion of the maxilla; and the pelvic fins are, in the majority, placed very far forwards.

Genus *Calamopleurus* (Agassiz), Dixon.

Among the undefined genera mentioned by name only in the ‘Poissons Fossiles’ is that of *Calamopleurus*,‡ proposed to be founded upon a Cretaceous fish from the North of Brazil. It was first established by Dixon,§ in an unsatisfactory manner, upon a similar fossil in Sir Philip Egerton’s collection, from the Chalk of Kent, which was figured and briefly noticed under the name of *Calamopleurus anglicus*. As shown by the type specimen and by two

* L. Agassiz, ‘Poiss. Foss.,’ Vol. v, Pt. ii, p. 109, Pl. 1xα, Figs. 5-8.

† A. E. Reuss, “Neue Fischreste aus dem böhmischen Pläner,” ‘Denkschr. math.-naturw. Cl. k. Akad. Wiss.,’ Vol. xiii (1857), pp. 39-41, Pl. iii.

‡ L. Agassiz, ‘Poiss. Foss.,’ Vol. v, Pt. i, p. 122.

§ F. Dixon, ‘Foss. Suss.,’ p. 375, Pl. xxxii, Fig. 12.

others in the British Museum (Nos. 36,170 and 49,055), the trunk of the fish is cylindrical, exhibiting little lateral compression; and the skull is small, with flattened roof, unornamented, and only marked by the pits of the sensory canals. The sclerotic capsule seems to have been ossified. The maxilla is long and slender, with the tooth-bearing margin slightly arched and provided with a close series of very minute teeth; the mandible is relatively deep, and bears a single row of elongate conical teeth, slightly curved, and considerably larger than those of the upper jaw, though likewise closely set. The opercular bones are large—especially the pre-operculum, which has a broad, thickened, anterior margin, from which radiating ridges and furrows diverge backwards. The scales are enormous, cycloid, and deeply overlapping, and show no markings beyond the concentric lines of growth, and some very faint divergent ribs revealed upon the exposed portion by the magnifying lens. There are two dorsal fins with spinous rays, and the pelvic fins are abdominal. Agassiz is probably correct in placing the genus with the Grey Mulletts in the family of *Mugilidæ*.

Prof. Cope* has described a genus, *Syllæmus*, from the Cretaceous of North America, which is very closely allied to *Calamopleurus*, and may even be identical. According to the description, however, *S. latifrons* seems to have a narrow mandible destitute of teeth, though this may perhaps be merely owing to imperfect preservation.

Genus *Cladocyclus*, Agassiz.

Two large oval scales, from the Chalk of Lewes, were originally figured by Agassiz† as pertaining to *Hypsodon*, but subsequently removed from that "genus" by the same naturalist (*ibid.*, p. 103) after he had had the opportunity of studying a more complete fossil from the Cretaceous rocks of North Brazil. The latter exhibited similar scales in natural association with vertebræ, which appeared very different from those most probably referable to *Hypsodon*; and Agassiz therefore regarded the fossils as indicating a new genus, for which the name of *Cladocyclus* suggested itself as most appropriate, in reference to the supposed branched condition of the

* E. D. Cope, "Report upon the Extinct Vertebrata obtained in New Mexico," Rep. U.S. Geol. Surv. Territ., Part ii, Vol. iv. (Palæontology), 1877, pp. 26-28, Pl. xxiii, Fig. 1. (*Syllæmus* was first founded in 1875, 'Vert. Cret. Form. West.', p. 180.)

† L. Agassiz, 'Poiss. Foss.', Vol. v, Pl. xxva, Figs. 5, 6.

canals forming the "lateral line" of the fish. Each of these scales is oval in shape, the long axis being vertical; and they were evidently deeply overlapping. The exposed portion is a sector only forming about one-third of the whole scale, and this is ornamented by numerous rounded tubercles, each with a pit in the middle. The overlapped area is marked by the delicate concentric lines of growth, and large interrupted diverging furrows; and I have seen no evidence of the branched condition of the "lateral line" referred to by Agassiz. A single English species has hitherto been recognized, namely, *C. levisiensis*; and the scales of the Brazilian form, *C. Gardneri*,* are very similar, but have slight concentric undulations parallel with the exposed posterior margin.

Genus *Platax*, Cuvier.

A small fossil from the Chalk of Washington, Sussex, was figured and briefly noticed by Dixon† under the name of *Microdon nuchalis*. This, however, is now preserved in the British Museum, and I have discovered that it is truly a Teleostean fish.‡ It is unfortunately too imperfect to be capable of very precise determination, but it is evidently an ally of the living "Sea-bats," and may be placed until more satisfactory specimens are available in the genus *Platax*, under the name of *P. nuchalis*. The body is deep, with the remains of large dorsal interspinous bones, indicating the original presence of a very high dorsal fin. The vertebral column is well ossified; and there is a distinct spine in front of each pelvic fin. Very similar, but perfect, fossils have been ascribed to *Platax* from the Upper Cretaceous of Mount Lebanon.§

Genus *Beryx*, Cuvier.

To the type-genus of the *Berycidae*, *Beryx* itself, only a single English Chalk species can be referred with much certainty—the *B. radians*, Agassiz.|| The living forms possess a relatively short dorsal fin, with three or four slender spines; and the spinous

* Named only by Agassiz, 'Poiss. Foss.,' Vol. v, Pt. i, p. 103.

† F. Dixon, 'Foss. Suss.,' p. 369, Pl. xxxii, Fig. 7.

‡ Smith Woodward, "On the so-called *Microdon nuchalis*, Dixon, from the Chalk of Sussex, a new Species of *Platax*," 'Ann. and Mag. Nat. Hist.' [5], Vol. xx (1887), pp. 342-4.

§ F. J. Pictet, 'Poissons Fossiles du Mont Liban,' 1850, p. 19, Pl. ii, Fig. 1. Pictet and Humbert, 'Nouv. Rech. Poiss. Foss. Mt. Liban,' 1886, p. 48, Pl. iv, Figs. 1-3. J. W. Davis, "Foss. Fishes Mt. Lebanon," 'Trans. Roy. Dublin Soc.' [2], Vol. iii, 1887, p. 524, Pl. xxv, Fig. 4.

|| Agassiz, 'Poiss. Foss.,' Vol. iv, p. 118, Pl. xivb, Fig. 7; Pl. xivc, Figs. 7-9. Dixon, 'Foss. Suss.,' p. 371, Pl. xxxvi, Fig. 4.

portion of the anal is similarly insignificant.* The Cretaceous *Beryx radians* appears to agree in these respects with the surviving species, but it is especially characterized by the enormous size of the pelvic fins (Pl. I, fig. 9), which reach backwards as far as the anal. The scales are of moderate size, smooth, and very delicately serrated on the posterior margin. A second Chalk species, *B. microcephalus*, Agass.,† is more doubtfully placed in this genus, and is readily distinguished by the extremely strong serrations of the posterior border of the scales. It is a small form, with relatively small head, and powerful dentition; but the fins, though robust, are imperfectly known.

Remains of the true *Beryx* also appear to have been discovered in the Chalk of Mt. Lebanon (*B. vexillifer* and *B. ovalis*).‡

Genus *Hoplopteryx*, Agassiz.

The genus *Hoplopteryx* was founded by Agassiz§ upon a fish (*H. antiquus*) from the Chalk of Westphalia, much like *Beryx* in general form, but especially differing in the characters of the dorsal and anal fins. The dorsal fin occupies the greater part of the back, and the anterior spinous portion, consisting of six very strong spines, has as great an extent as the soft portion behind. There are also four large and strong spines in advance of the anal fin; and the pelvic fins possess at least seven soft rays, in addition to the usual spine.

No English fossils were referred at the time to the same type, but it now appears that at least two species are represented in the Chalk of Kent and Sussex. The common so-called *Beryx levisiensis*, or *Beryx ornatus*,|| is truly referable to *Hoplopteryx*,

* A fine figure of the skeleton of a recent species has lately been published by A. Günther, "Report on the Deep-Sea Fishes," 'Challenger Reports,' Zoology, Vol. xxii (1887), Pl. vi.

† L. Agassiz, 'Poiss. Foss.,' Vol. iv, p. 119, Pl. xivb, Figs. 3-6; Pl. xivc, Fig. 10. Dixon, 'Foss. Suss.,' p. 372, Pl. xxxiv, Fig. 3.

‡ Pictet and Humbert, 'Nouv. Rech. Poiss. Foss. Mt. Liban,' p. 30, Pl. ii, Figs. 1-3. J. W. Davis, "Foss. Fishes Mt. Lebanon," 'Trans. Roy. Dublin Soc.' [2], Vol. iii, p. 508, Pl. xxvii, Fig. 4.

§ L. Agassiz, 'Poiss. Foss.,' Vol. iv, pp. 131, 2, Pl. xvii, Figs. 6-8.

|| *Zeus levisiensis*, Mantell, 'Foss. South Downs,' 1822, p. 234, Pls. xxxv, xxxvi. *Beryx ornatus*, Agassiz, 'Poiss. Foss.,' Vol. iv, p. 115, Pl. xiva, Pl. xivb, Figs. 1-2; Pl. xivc, Figs. 1-6, Pl. xivd. Also Dixon, 'Foss. Suss.,' p. 371, Pl. xxxvi, Fig. 3; Pl. xxxiv, Figs. 1, 4, 5. The species is also included in the genus *Beryx* in the present writer's 'List of Fossil Berycidae,' 'Geol. Mag.' [3], Vol. iv (1887), pp. 357-8, which appears to include all fossil forms discovered before the date of publication, except *Beryx Valenciennesi*, Hébert, 'Mém. Soc. Géol. France' [2], Vol. v (1854), p. 349, Pl. xxvii, Fig. 2.

as shown by its dorsal and anal fins ; and so also (as Mr. J. W. Davis has pointed out*) is the large species called *Beryx superbus* by Dixon.† In *Hoplopteryx levisiensis* there are six powerful spines in advance of the dorsal fin, occupying as great a length of the back as the succeeding soft rays ; and three (or possibly more) similar spines occur in front of the anal. Each pelvic fin has at least eight soft rays in addition to the spine ; and the posterior margins of the scales are strongly serrated. *Hoplopteryx superbus*, if really specifically distinct, and not merely differing in age, may be said to be distinguished by its stronger skeleton, fins, and scales ; and the latter seem to have a greater antero-posterior measurement in proportion to their height.

Genus *Berycopsis*, Dixon.

Berycopsis is a Berycoid with scales of moderate size, thick, and remarkable for the absence of serrations upon their posterior border. The scales are smooth, or only ornamented with very delicate radiating lines, visible under a lens. The fin-rays of the dorsal and anal fins are especially robust, and in advance of the former there are not less than six short, strong spines, gradually increasing in length posteriorly, and somewhat spaced out ; the soft portion of the fin seems to have been continuous with the spinous portion, but it is considerably higher. There are at least seven soft rays in each pelvic fin, in addition to the usual spine ; but the anal and caudal still remain unknown.

The only species hitherto recognized is *B. elegans*,‡ of which the type-specimen was obtained from the Chalk of Sussex, and is preserved in Mr. Willett's collection in the Brighton Museum.

Genus *Stenostoma*, Dixon.

This genus is founded upon a specimen in the Dixon Collection (British Museum), and probably belongs to the Berycidae, though the characters of its fins are still imperfectly known. It is a little deep-bodied fish, with small, deeply overlapping ctenoid scales. The head-bones are coarsely marked with tubercles and ridges, and (as shown by No. 63, Willett Coll.) the operculum is of

* J. W. Davis, 'Foss. Fishes Mt. Lebanon,' p. 514. Mr. Davis also well remarks that the so-called *Beryx syriacus*, P. and H., belongs to this genus. The new species *Hoplopteryx spinosus*, Davis, however, is at least generically distinct, as shown by the characters of its median fins.

† F. Dixon, 'Foss. Suss.,' p. 372, Pl. xxxvi, Fig. 5.

‡ F. Dixon, 'Foss. Suss.,' 1850, p. 372, Pl. xxxv, Fig. 8.

triangular shape. The single known species is *S. pulchella*,* and the fish may perhaps be related to the small-scaled existing *Trachichthys*;† but it certainly has no affinity with the Brazilian Cretaceous fossil, *Rhacolepis*, as suggested by Dixon, the latter having cycloid scales and pertaining to the herring-family.‡

Genus *Homonotus*, Dixon.

The genus *Homonotus* is too imperfectly known to be placed with certainty among the *Berycidae*, though this is its most probable position. A single species, *H. dorsalis*, was figured by Dixon,§ but no notice of it beyond the original brief paragraph appears to have been hitherto published.|| It differs from all other Berycoids of the Chalk in the thinness of its ctenoid scales; and also in the length and slenderness of the spinous rays in front of the dorsal fin. The last-named spines are not less than twelve in number, and the fin occupies the greater part of the back, commencing far in advance of the opposing anal, though it is uncertain whether the spinous and soft portions were connected. In front of the anal fin there are four large, strong spines successively increasing in size.

The precise nature of the following genera of fishes cannot be determined, owing to the imperfection of the fossils upon which they are respectively founded.

Genus *Cælorhynchus*, Agassiz.

This uncertain genus was founded by Agassiz upon a slender elongated fossil which he considered to be the snout of an extinct Sword-fish.¶ The fossil tapers at its extremity to a blunt point, but the base is unknown. It is round in section, with a small central cavity divided into two towards the upper end, and the external surface is longitudinally grooved. The extremity readily splits into two symmetrical halves along a division-plane in the

* F. Dixon, 'Foss. Suss.,' p. 373, Pl. xxxvi, Fig. 2.

† See figures of A. Günther, 'Report on the Deep-Sea Fishes,' Pl. v, Figs. c, d.

‡ Smith Woodward, "On the Fossil Teleostean Genus *Rhacolepis*," 'Proc. Zool. Soc.,' 1887, pp. 535-542, Pls. xlv, xlvii.

§ F. Dixon, 'Foss. Suss.,' p. 372, Pl. xxxv, Fig. 2.

|| A small fish described by Mr. J. W. Davis (*op. cit.*, p. 519, Pl. xxv, Fig. 3), from the Cretaceous of Mount Lebanon, under the name of *Homonotus pulcher*, is certainly not referable to this genus. The dorsal fin commences opposite the anterior extremity of the anal, and the thick scales are quite distinct in character. The specimen is, indeed, very suggestive of the genus *Pycnosterinx*.

¶ L. Agassiz, 'Poiss. Foss.,' Vol. v, Pt. i, p. 92.

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wall dividing the internal cavity. According to Prof. Williamson,* the microscopical structure of the fossil is closely similar to that of the dermal armour of the Coffer-fish (*Ostracion*), and it is therefore almost certainly a dermal spine. Only one small species, *Cælorhynchus cretaceus*,† is known from the Chalk; but much larger examples are discovered in the Eocenes. One fine specimen from the Bracklesham Beds in the British Museum (No. 25,729a) measures no less than ten inches in length, and its diameter at the base is only about half an inch.

Genus *Ancistrodon* (Debey), Roemer.

The name of *Ancistrodon* was originally given by Debey, in MS., to some detached fish-teeth from the Chalk of Aix-la-Chapelle, and subsequently defined by Roemer,‡ who discovered and described similar specimens in the corresponding formations of Texas, U.S.A. Bosquet and Ubaghs afterwards recorded other examples from the Chalk of Maastricht; in 1881 Schlüter figured and described the original teeth from Aix; and lastly, Prof. W. Dames,§ of Berlin, has published an elaborate study of the "genus," defining several "species," both Cretaceous and Tertiary.

The teeth in question are readily recognized by their laterally-compressed form, and the peculiar shape of the crown, which is very suggestive of the claw of such an animal as a cat. This is hard and enamelled, and fixed upon a long base, which tapers and varies in width but slightly. I have met with several detached specimens from the English Chalk, and there are three in the British Museum. The smallest is from Hart Hill, near Charing, Kent; one, somewhat larger, from Lewes (Pl. I, Fig. 10); and another, of considerable size, from an uncertain locality in Sussex.

It is obviously unwise to propose specific names for fossils of so problematical a nature, and the "genus" itself must only be regarded as provisional. The teeth were originally referred in

* W. C. Williamson, "Investigations into the Structure and Development of the Scales and Bones of Fishes," 'Phil. Trans.' 1849, Pl. xliii, Figs. 35-37; *ib.*, 1851, p. 668.

† F. Dixon, 'Foss. Suss.' p. xii, Pl. xxxii, Fig. 10.

‡ F. Roemer, 'Die Kreidebildungen von Texas und ihre organischen Einschlüsse,' 1852, p. 30, Pl. i, Fig. 10.

§ W. Dames, "Ueber *Ancistrodon*, Debey," 'Zeitsch. deutsch. geol. Gesell,' 1883, pp. 655-670, Pl. xix. Full references to previous literature are given in this paper.

error to an extinct shark, and it cannot be said that their true relationships are still placed beyond doubt. They are regarded by Dames as the pharyngeal teeth of Teleosteans ; but it seems quite as likely that they are the anterior prehensile teeth of Pycnodonts.

Genus *Plethodus*, Dixon.

Some portions of flat crushing teeth, from the Chalk of Sussex, were placed by Dixon* in a genus named *Plethodus*, and referred to fishes of the Selachian order ; and one similar specimen has subsequently been described by Fritsch as *Chimæra furcata*.† The thin superficial layer of these fossils is punctate, and the tooth-substance around each punctation has a concentric structure ; beneath this layer the tooth consists of vascular dentine, with the principal vessels at right-angles to the grinding surface ; and the base of the tooth is formed by a layer of true bone, with very distinct lacunæ. The plates are of varying form, sometimes oval, sometimes elongated and bifurcated at one extremity, sometimes convex, and sometimes concave ; those occurring in the Gault and Cambridge Greensand are also often leaf-shaped, with a depression at one end, and the vertical margin ornamented with small tubercles. Occasionally two plates are found naturally superposed, like the pharyngeal dental plates of the Eocene *Phyllodus*.

That these fossils are truly teeth appears certain ; but whether they are all of one character, and belong to one genus, may perhaps be considered doubtful. Many of them—if not all—belong undoubtedly to bony fishes. The teeth are occasionally found connected with bone, and one specimen in Mr. Willett's collection shows "*Plethodus*" so placed in the midst of a skull as to suggest its connection with the pharyngeal bones. Two species are recognized, *P. oblongus* and *P. expansus*.

IV.—REVISED LIST OF THE FOSSIL VERTEBRATA OF THE ENGLISH CHALK.

As a result of the investigations briefly summarized in the preceding pages, I venture to regard the following as a revised list of the English Chalk Vertebrata, so far as can be determined from known specimens. Of the species marked thus * the type-specimens are preserved in the British Museum, while of those marked

* F. Dixon, 'Foss. Suss.,' p. 366, Pl. xxxii*, Fig. 4; Pl. xxxiii, Fig. 2.

† A. Fritsch, 'Rept. u. Fische böhm. Kreideform.,' pp. 16, 17.

thus † the types are to be found in Mr. Willett's collection in the Brighton Museum.

REPTILIA.

Order CHELONIA.

- * (?) *Chelone Hoffmanni*.
- * *Cimoliochelys Benstedii* (Mantell), Owen.

Order SAUROPTERYGIA.

- * *Polyptychodon interruptus*, Owen.
- * *Plesiosaurus Bernardi*, Owen.
- * „ *constrictus*, Owen.
- * „ *Smithii*, Owen.

Order ICHTHYOSAURIA.

Ichthyosaurus campylodon, Carter.

Order PYTHONOMORPHA.

- * *Mosasaurus anceps* (Owen), A. S. W.

Order LACERTILIA.

- * *Dolichosaurus longicollis*, Owen.
- † *Coniosaurus crassidens*, Owen.
- Rhaphiosaurus subulidens*, Owen.

Order PTEROSAURIA.

- * *Ornithocheirus giganteus*, Bowerb.
- * „ *Cuvieri*, Bowerb.
- * „ *compressirostris*, Owen.

Order DINOSAURIA.

- * *Acanthopholis horridus*, Huxley.

PISCES.

Order SELACHII.

- * *Acrodus* (?) *Illingworthi*, Dixon.
- * *Acrodus levis*, A. S. Woodw.
- * *Corax falcatus*, Agass.
- „ *pristodontus*, Agass.
- * *Drepanephorus canaliculatus* Egert.
- * *Synechodus dubrisiensis* (Mackie), A. S. W.
- * *Notidanus microdon*, Agass.
- „ *pectinatus*, Agass.

- * *Odontaspis raphiodon*, Agass.
- „ *subulata*, Agass.
- * *Otodus appendiculatus*, Agass.
- „ *crassus*, Agass.
- „ *semiplicatus*, Münster.
- * *Oxyrhina crassidens*, Dixon.
- * „ *Mantelli*, Agass.
- * *Ptychodus decurrens*, Agass.
- „ *latissimus*, Agass.
- * „ *mammillaris*, Agass.
- * „ *Oweni*, Dixon.
- * „ *polygyrus*, Agass.
- „ *rugosus*, Dixon.
- * *Scylliodus antiquus*, Agass.
- † *Squatina Cranei*, A. S. Woodw.

Order CHIMÆROIDEI.

- * *Edaphodon Agassizii* (Buckl.).
- „ *crassus*, Newton.
- „ *gigas*, Egert.
- * „ *Mantelli* (Buckl.).
- „ *Sedgwickii*, Agass.
- † *Elasmodectes Willetti*, Newton.
- „ *Ischyodus brevirostris*, Agass. (var.).
- „ *incisus*, Newton.

Order GANOIDEI.

- † *Belonostomus attenuatus*, Dixon.
- * „ *cinctus*, Agass.
- * *Cælodus angustus* (Agass.), Zittel.
- „ *cretaceus* (Agass.), Zittel.
- * „ (?) *faba* (Agass.), Zittel.
- † „ *parallelus* (Dixon), Zittel.
- * *Gyrodus cretaceus*, Agass.
- * *Lophiostomus Dixoni*, Egerton.
- * *Macropoma Mantelli*, Agass.
- † *Microdon* (?) *occipitalis*, Dixon.
- * *Neorhombolepis excelsus*, A. S. Woodw.
- * *Prionolepis angustus*, Egerton.
- Rhombic-scaled ganoid, gen. non det.

Order TELEOSTEI.

- * *Acrognathus boops*, Agass.
 - * *Aulolepis typus*, Agass.
 - † *Berycopsis elegans*, Dixon.
 - * *Beryx radians*, Agass.
 - * „ (?) *microcephalus*, Agass.
 - * *Calamopleurus anglicus*, Dixon.
 - * *Cimolichthys levesiensis*, Leidy.
 - * *Cladocycclus levesiensis*, Agass.
 - * *Daptinus* (?) *intermedius*, Newton.
 - * *Dercetis elongatus*, Agass.
 - * *Enchodus levesiensis* (Mantell), Agass.
 - † *Homonotus dorsalis*, Dixon.
 - * *Hoplopteryx levesiensis* (Mantell), A. S. W.
 - * „ *superbus* (Dixon), Davis.
 - * *Ichthyodectes elegans*, Newton.
 - * „ *minor* (Dixon), Newton.
 - * *Osmeroides levesiensis* (Mantell), Agass.
 - † „ (?) *crassus*, Dixon.
 - * *Pachyrhizodus basalis*, Dixon.
 - * „ *Gardneri* (Mason), Davies MS.
 - † „ *gracilis* (Owen), Davies MS.
 - * *Platax nuchalis* (Dixon), A. S. W.
 - † *Plethodus expansus*, Dixon.
 - † „ *oblongus*, Dixon.
 - * *Plinthophorus robustus*, Günther.
 - † *Pomognathus eupterygius*, Dixon.
 - * *Portheus Mantelli*, Newton.
 - * „ *Daviesii*, Newton.
 - * „ *sp. ind.*, Newton.
 - * *Protosphyraena ferox*, Leidy.
 - * „ *minor* (Agassiz), A. S. W.
 - * *Saurocephalus* (?) *striatus*, Agass.
 - * *Stenostoma pulchella*, Dixon.
 - * *Stratodus anglicus*, A. S. Woodw.
 - Tomognathus mordax*, Dixon.
 - Elopine Clupeoid, gen. non det.
- INCERTÆ SEDIS.
- Cælorhynchus cretaceus*, Dixon.
 - * *Ancistrodon*, sp.

The following names applied to vertebrate fossils from the English Chalk, are here regarded as synonyms. It has been thought most convenient to arrange these in a separate alphabetical list, the accepted determination of each being added, and thus showing precisely the fate of many of the names which still survive in collections.

SYNONYMS.

- Acrodontosaurus Gardneri*, Mason.—*Pachyrhizodus Gardneri*.
Acrodus rugosus, Agassiz.—*Drepanophorus canaliculatus* (?).
 „ *cretaceus*, Dixon.— „ „
Acrotemnus faba, Agassiz.—*Cælodus faba*.
Amia? *lewesiensis*, Mantell.—*Macropoma Mantelli*.
† *Aulodus Agassizi*, Dixon.—*Ptychodus* (?) *polygyrus*.
Beryx ornatus, Agassiz.—*Hoplopteryx lewesiensis*.
 „ *superbus*, Dixon.— „ *superbus*.
* *Caturus similis*, Agassiz.—Genus non det.
Cestracion canaliculatus, Egerton.—*Drepanophorus canaliculatus*.
Chelone Benstedii, Owen.—*Cimoliochelys Benstedii*.
Cimoliornis diomedeus, Owen.—*Ornithocheirus giganteus*.
* *Corax maximus*, Dixon.—*Corax falcatus*.
Emys Benstedii, Mantell.—*Cimoliochelys Benstedii*.
Enchodus halocyon, Agassiz.—*Enchodus lewesiensis*.
Erisichthe Dixoni, Cope.—*Protosphyraena ferox*.
Esox lewesiensis, Mantell.—*Enchodus lewesiensis*.
Gyrodus angustus, Agassiz.—*Cælodus angustus*.
† „ *conicus*, Dixon.—*Gyrodus cretaceus*.
Hypsodon lewesiensis, Agassiz.—*Pachyrhizodus Gardneri*.
Portheus Mantelli.
Portheus sp. ind.
 „ *minor*, Dixon.—*Ichthyodectes minor*.
* *Lamna acuminata*, Agassiz.—*Oxyrhina Mantelli*.
Leiodon anceps, Owen.—*Mosasaurus anceps*.
Microdon nuchalis, Dixon.—*Platax nuchalis*.
Mosasaurus stenodon, Charlesworth.—*Mosasaurus anceps*.
 „ *gracilis*, Owen.—*Pachyrhizodus gracilis*.
Muræna? *lewesiensis*, Mantell.—Worm-burrows.
* *Orthagoriscus* sp., Dixon.—Chelonian dentary bone.
Osteornis diomedeus, Gervais.—*Ornithocheirus giganteus*.
* *Phacodus punctatus*, Dixon.—Indeterminable Pycnodont Teeth

- * *Polyptychodon continuus*, Owen.—*Polyptychodon interruptus*.
Pterodactylus compressirostris, Owen.—*Ornithocheirus compressirostris*.
 „ *conirostris*, Owen.— „ *giganteus*.
 „ *Cuvieri*, Bowerbank.— „ *Cuvieri*.
 „ *giganteus*, Bowerbank.— „ *giganteus*.
Ptychodus arcuatus, Agassiz.—*Protosphyræna* sp.
 „ *articulatus*, Agassiz.—(?) „
 „ *altior*, Agassiz.—*Ptychodus mammillaris*.
 „ „ Dixon.— „ *rugosus*.
 „ *depressus*, Dixon.— „ *decurrens*.
 „ *gibberulus*, Agassiz.—*Protosphyræna* sp.
 „ *paucisulcatus*, Dixon.—*Ptychodus latissimus*.
 „ *spectabilis*, Agassiz.—*Protosphyræna* sp.
Pycnodus cretaceus, Agassiz.—*Cœlodus cretaceus*.
 „ *parallelus*, Dixon.— „ *parallelus*.
Rhaphiosaurus lucius, Owen.—*Rhaphiosaurus subulidens*.
Salmo lewesiensis, Mantell.—*Osmeroides lewesiensis*.
Saurocephalus lanciformis, Agassiz (*non* Harlan).—*Protosphyræna ferox*.
Saurodon Leanus, Agassiz (*non* Hays).—*Cimolichthys lewesiensis*.
Selache Davisi, Hasse.—*Ptychodus* sp. ind.
Spinax major, Agassiz.—*Drepanophorus canaliculatus*.
* *Strophodus asper*, Agassiz.—Fragment of Crustacean.
Tetrapterus minor, Agassiz.—*Protosphyræna minor*.
* *Tomognathus leiodus*, Dixon.—*Tomognathus mordax*.
* *Xiphias Dixoni*, Leidy.—*Protosphyræna ferox*.
Zeus lewesiensis, Mantell.—*Hoplopteryx lewesiensis*.

V.—GENERAL KEY TO THE KNOWN VERTEBRATE FOSSILS OF THE ENGLISH CHALK.

BONES.

- | | |
|---------------------------|---|
| (i) Delicate, squamous. | Fishes ; Chelonian. |
| (ii) Hollow, thin-walled. | Pterodactyles. |
| (iii) More massive. | Dinosaurian ; Mosasaurian ;
Plesiosaurian ; Ichthyosaur-
ian ; Chelonian ; Snout of
<i>Protosphyræna</i> . |

TEETH.

- (i) With base having appearance of no connection with sockets or bone. Selachian.

(A) Depressed, crushing. *Ptychodus*; *Drepanephorus*;
Acrodus; some *Hybodus*
and *Synechodus*.

(B) Conical.

(a) Much compressed, edge serrated in large specimens.

Corax.

(b) Somewhat thicker, not serrated; rarely traces of lateral denticles.

Oxyrhina, *Squatina*.

(c) Similar, with large lateral denticles.

Otodus.

(d) Long and cylindrical, with lateral denticles.

Odontaspis; *Scylliodus*; some *Hybodus*.

(e) Series of compressed cones on one base.

Notidanus.

- (ii) Fixed in sockets or attached to bone.

(A) Flattened, crushing. *Gyrodon*; *Cælodus*; *Belonostomus*; *Plethodon*.

(B) Conical, with sharp edges only in part.

(a) With short base, or none.

Dolichosaurus; *Coniosaurus*; *Cimolichthys*;
Pomognathus; *Tomognathus*; *Porteus*;
Ichthyodectes; *Belonostomus*.

(b) With comparatively large base.

Polyptychodon; *Plesiosaurus*; *Mosasaurus*;
Pachyrhizodus; *Stratodus*.

(C) Much laterally compressed, with sharp edges.

(a) Edges smooth.

Ornithocheirus; *Protosphyrapa*; *Daptinus*; *Ancistrodon*.

(b) Edges dentated. *Acanthopholis*.

(D) Portions of bone with dentinal areas. Chimæroid Fishes.

SCUTES AND SCALES.

- (i) Arrow-head-shaped.

Dercetis; *Plinthophorus*.

(ii) Cycloid scales.

Osmeroides; *Acrognathus*; *Aulolepis*; *Pachyrhizodus*;
Cladocyclus; *Calamopleurus*; *Berycopsis*.

(iii) Ctenoid scales.

Beryx; *Hoplopteryx*; *Stenostoma*; *Homonotus*.

(iv) Ganoid scales.

(A) Rhombic.

Lophiostomus; *Neorhombolepis*; *Belonostomus*;
Gyrodus; *Cælodus*; *Prionolepis*.

(B) Round and much ornamented.

Macropoma.

SPINES.

(i) Round, ribbed.

Cælorhynchus.

(ii) Laterally-compressed, smooth.

Drepanephorus.

EXPLANATION OF PLATE I.

FIG. 1.—*Neorhombolepis excelsus*, A. S. Woodw., nat. size; Lower Chalk, Upper Halling, Kent. *op.* operculum. *p.* pectoral fin. *p. cl.* post-clavicular scales. *S. op.* suboperculum. (B.M., No. 43,077.)

FIG. 2.—Scales of the so-called *Lepidotus punctatus*, Agassiz MS., nat. size; Blue Bell Hill, Burham, Kent. Collection of Mr. S. J. Hawkins, F.G.S.

FIG. 3.—Portion of dentition of *Stratodus anglicus*, A. S. Woodw., nat. size; Glynde, Sussex. *3a.* Section of tooth. (B.M., No. 49,906.)

FIG. 4.—Anterior portion of left dentary bone of ditto, showing bases of two series of teeth, nat. size; Lower Chalk, Southeram, near Lewes. The depth of the bone is not clearly indicated, owing to the aspect shown being half-superior, half-lateral. (B.M., No. 49,780.)

FIG. 5.—Skull and mandible of *Enchodus levesiensis*, Mant. sp., side view, nat. size; Lewes. *d.* Dentary bone. *mx.* maxilla. *pmx.* premaxilla. (B.M., No. P. 5,415.)

FIG. 6.—Palato-pterygoid arcade of ditto, nat. size; Lewes. *ectp.* ectopterygoid. *entp.* entopterygoid. *pal.* palatine. (B.M., No. P. 5,416.)

FIG. 7.—Scute of "lateral line" of *Dercetis elongatus*, Agass., eight times nat. size; Norfolk. Collection of Dr. George J. Hinde, F.G.S.

FIG. 8.—Scale of *Pachyrhizodus*, nat. size; Sussex. (B.M., No. P. 1,808.)

FIG. 9.—Pelvic fin, and fragment of ditto, of *Beryx radians*, Agass., nat. size; Kent. (B.M., No. 39,429.)

FIG. 10.—Tooth of *Ancistrodon*, nat. size; Lewes. (B.M., No. 49,956.)

