The great inequality and difference of shape of the opposite valves ascribed to the same species are also characteristic and peculiar features.

EXPLANATION OF PLATE VII.

- FIG. 1.—*Trochoceras spurium*, Salter (a 466). Wenlock Shale: Bulth Bridge. Drawn nat. size.
 FIG. 2.—*Orthoceras fluctuatum*, Salter (a 611). Lower Bala (Llandeilo): Wellfield, Bulth. $\times$ twice nat. size.
 FIG. 3.—*Pterinea exasperata*, Salter (a 816). Wenlock Limestone: Dudley. $\times 1\frac{1}{2}$ nat. size.
 FIG. 4.—Ditto (a 813).
 FIG. 5.—Ditto (a 816), 4 ribs enlarged 4 times nat. size, to show ornamentation.
 FIG. 6.—*Pterinea condor*, Salter (a 809). Lower Ludlow Beds: Dudley. Left valve. Nat. size.
 FIG. 7.—Ditto, right valve (a 810), nat. size.

II.—ON *CAMPYLOPRION*, A NEW FORM OF *EDESTUS*-LIKE DENTITION.

By Dr. C. R. EASTMAN, of Cambridge, Mass., U.S.A.

(PLATE VIII.)

IN the January number of the GEOLOGICAL MAGAZINE for 1886, an elaborate description is given by Dr. Henry Woodward of a peculiar ichthyic structure from the Carboniferous of Western Australia, which is referred by him provisionally to *Edestus*, under the specific title of *E. davisii*. Interesting comparisons are drawn between this and other known species of *Edestus*, and the hypothesis advanced that it is a pectoral fin-spine, resembling in its segmented character the Cretaceous *Pelecopterus*. This segmentation, which is so conspicuous a feature of *Edestus*, is attributed by Dr. Bashford Dean in his book on "Fishes, Living and Fossil," to a metameral origin, and he follows Leidy, Owen, Cope, Newberry, and others in interpreting all this class of remains as dorsal fin-spines.

As early as 1855 Louis Agassiz¹ compared the type-specimen of *Edestus minor*, Newberry, with the rostral prolongation of *Pristis*, and pronounced it a dermal defence, pertaining probably to the snout region of a shark or skate. Quite recently this hypothesis has been revived by Dr. A. Karpinsky, Director of the Russian Geological Survey, in his superb memoir on *Helicoprion*,² a spirally coiled form whose segments resemble those of *Edestus*, and is regarded by the author as a powerful weapon placed above the snout in the median line. To this Permo-Carboniferous genus, *Helicoprion*, the Russian Director also refers the Australian form described by Dr. Henry Woodward as *Edestus davisii*, which differs principally in the lesser extent of its spiral. In an appreciative review of his monograph, Dr. Arthur Smith Woodward³ questions the probability of Karpinsky's conjecture, and cites a recent discovery made by Dr. Traquair in the Lower Devonian of Forfarshire, which "proves

¹ Proc. Amer. Assoc. Adv. Sci., 1855 (1856), p. 229.

² Verh. k. russ. min. Ges. St. Petersburg, 1899, ser. II, vol. xxxvi, No. 2.

³ GEOL. MAG., 1900, Dec. IV, Vol. VII, p. 33.

GM Woodward del. et lith.

West, Newnan imp.

Ordovician and Silurian Mollusca.

FIG. 1.

FIG. 2.

Symphysial Teeth of Palæozoic Sharks.

FIG. 1.—*Campodus variabilis* (Newb. & W.): Coal-measures, Cedar Creek, Nebraska.

FIG. 2.—*Campyloprion anneclans*, C. R. Eastman, gen. et sp. nov. (loc. unknown).
(About one-third natural size.)

undoubtedly that there were Palæozoic sharks with sharp, piercing teeth, which were never shed, but became fused into whorls as the animal grew."

The same memoir was also reviewed by the present writer,¹ who brought forward additional instances of coiling amongst Palæozoic sharks, and was inclined to look upon the segments of *Helicoprion* as veritable teeth. Finally, a fortunate discovery of the symphysial dentition of the Carboniferous genus *Campodus*, made by Professor E. H. Barbour, Director of the Nebraska University Geological Survey, threw new light on the matter, and furnished ground for a positive statement that the fused segments of *Edestus* and *Helicoprion* are actually teeth belonging to the anterior series of Cestraciont sharks. The evidence for this was presented by the writer before the Denver meeting of the American Association for the Advancement of Science, and in the published abstract of that paper² the arrangement of the anterior series in *Campodus variabilis* (Newb. & W.) was briefly described. A second specimen in the Museum of Comparative Zoology at Cambridge, Mass., from the Coal-measures of Osage County, Kansas, exhibits the symphysial series in natural association with the lateral. Professor Barbour's specimen, shown in the accompanying Plate VIII, Fig. 1, is more perfect in some respects, but has none of the lateral series associated with it.

Each individual of *Campodus* is known to have possessed at least three series of coalesced anterior or symphysial teeth. As indicated by the marks of contact, there was a median arched azygous series in one jaw (presumably the lower, as is the case in *Cestracion*, *Chlamydoselache*, and other existing sharks), opposed to which in (presumably) the upper jaw were two corresponding series separated from each other by a slight interval. The orientation of both the symphysial and lateral teeth of *Campodus* may be determined from the fact that their coronal buttresses are directed outward, instead of inward, as was erroneously supposed by Messrs. St. John and Worthen. Several series of anterior teeth, all coiled in a single plane, are known to have been present in the same mouth of *Campodus*, *Protodus*, *Periplectrodus*, and certain Coeliodonts, hence it is probable that a like condition was true of *Edestus* and *Helicoprion*. In the two last-named genera it was rightly pointed out by Smith Woodward that the absence of lateral facettes or marks of contact with adjoining whorls indicates that the series were separated from one another, as in the existing *Chlamydoselache*. In the light of the now clearly apparent odontological nature of *Edestus* and *Helicoprion*, together with their Cestraciont affinities, it may be pertinent to inquire whether the huge fin-spines from the Carboniferous, such as *Oracanthus*, *Phoderaacanthus*, *Stichacanthus*, and the like, were not borne by creatures having an *Edestus*- or *Campodus*-like dentition.

¹ Amer. Nat., 1900, vol. xxxiv, p. 579.

² Science, n.s., 1901, vol. xiv, p. 795.

DESCRIPTION OF *CAMPYLOPRION ANNECTANS*, gen. et sp. nov.
(Pl. VIII, Fig. 2; and Woodcut, Fig. 3, in text.)

In the same category with *Edestus* and *Helicoprion* must be placed a new genus of Palæozoic Cestracions, known as yet only by its symphyseal dentition, for which the name *Campyloprion* is proposed, with the type species of *C. annectans*. This is founded on a unique specimen belonging to Tufts College Museum, Boston, the description of which follows. The new genus is also held to include two species originally assigned to *Edestus*, namely, *E. davisii*, Woodward, and *E. lecontei*, Dean. The former of these has been discussed in its relations to other *Edestus*-like structures by Woodward, Dean, and Karpinsky, and was transferred by the last-named author to *Helicoprion*. For the sake of comparison we may briefly summarize the distinguishing characters of these four closely related genera, as follows:—

1. *Campodus*.—Anterior series of thirteen or more teeth fused into a semicircular arch, their outer (anterior) coronal margins prominently buttressed, and their coronal apices rather obtuse and not serrated; the teeth only slightly overriding one another at their extremities, not much laterally compressed, and very much larger than the immediately adjoining lateral series, which also have their buttresses directed outward. Type, *C. agassizianus*, Koninck.

2. *Edestus*.—Anterior series of seven or more fused teeth only moderately arched and laterally compressed; coronal apices acuminate and serrated along the sharpened anterior and posterior margins; bases strongly reflected forward, invaginated, and fused throughout. Lateral series unknown. Type, *E. vorax*, Leidy.

3. *Campyloprion*.—Anterior series of twenty or more fused teeth considerably arched and much laterally compressed; coronal apices rather obtuse, and coarsely serrated along the sharpened anterior and posterior margins; teeth curved or bent forward, overriding one another toward their extremities and fused for the greater portion of their length. Type, *C. annectans*, sp. nov.

4. *Helicoprion*.—Anterior series consisting of upwards of 150 fused teeth, very similar to the last in form, but coiled into approximately $3\frac{1}{4}$ whorls; coronal apices acute and finely serrated along the sharpened anterior and posterior margins; enamel extending far down the lateral faces; teeth more or less strongly curved forward, overlapping and fused for a portion of their length; two lateral grooves extending along the spiral near the bottom. Lateral series unknown. Type, *H. bessonowi*, Karpinsky.

Arranged in the above order we are enabled to note the progressive stages by which the typical Cestracient dentition of *Orodus* and *Campodus*, occurring in the Carboniferous, passed into the excessively modified spirals of *Helicoprion* in the Permian. Moreover, the chief interest attaching to *Campyloprion* is on account of its intermediate position, two of its species linking it with *Edestus*, as already observed, and a third, as denoted by its trivial title, marking the transition to *Helicoprion*.

For the opportunity to describe the interesting series of teeth shown in Plate VIII, Fig. 2, and section in text, Fig. 3, the writer is indebted to his friend Dr. J. S. Kingsley, of Tufts College, in whose custody it has been for many years. Unfortunately nothing is known of the history of the specimen prior to its coming to Tufts, except that it was procured for the Museum by the late Professor Marshall. While its age may be confidently attributed to the Upper Carboniferous or Permian, there is no clue as to its locality. The specimen

is arcuate in form, with an extreme length of about 24 cm., and comprising twenty fused teeth, only four of which, however, are perfectly preserved. A transverse section of the specimen taken vertically from the apex of the largest tooth, where the height is about 8 cm., is shown in Fig. 3. All the teeth have suffered greatly from the effects of weathering, which has removed most of the enamel, and from post-mortem abrasion. In general form they resemble those of *Helicoprion bessonowi*, but are less angularly bent, in which respect they differ also from *C. davisii*; in addition, their apices are more obtuse and more coarsely serrated. Both of these species of *Campyloprion* differ from the Russian form in their lesser degree of curvature, and it is extremely improbable that either of them was coiled into a complete spiral. Neither do they exhibit the double lateral grooves which traverse the spirals of *Helicoprion*. It is possible that the indistinct patches of enamel observed along the base of the present specimen may represent an adjacent series of small teeth, such as occur in juxtaposition to the symphyseal series of *Campodus variabilis*. A more detailed account of the dentition of the latter form will be given in a forthcoming number of the Bulletin of the Museum of Comparative Zoology.

Vertical section of Fig. 2.
Campyloprion annectans.

EXPLANATION OF FIGURES.

- PL. VIII, FIG. 1.—*Campodus variabilis* (Newb. & W.). Coal-measures: Cedar Creek, Nebraska. Symphyseal series of teeth belonging (presumably) to the lower jaw, viewed from the right-hand side. Original preserved in the Museum of Nebraska State University at Lincoln. Reduced to about one-half nat. size.
- PL. VIII, FIG. 2.—*Campyloprion annectans*, gen. et sp. nov. Carboniferous or Permian: locality unknown. Left lateral aspect of a portion of the anterior dentition, showing portions of 20 coalesced teeth, supported at their bases by a band of calcified cartilage. Reduced.
- FIG. 3 (in text).—*Campyloprion annectans*. Vertical cross-section of specimen shown in Fig. 2, passing through apex of largest tooth in the series. Reduced to about one-third nat. size.

III.—THE VENTRAL INTEGUMENT OF TRILOBITES.¹

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(PLATES IX-XI.)

IN previous papers by the writer on the structure and appendages of *Triarthrus*,² no attempt has been made to describe or illustrate the character of the ventral integument, especially in the sternal or

¹ Reprinted by permission from the Amer. Journ. Sci. [4], vol. xiii (1902), pp. 165-174.

² C. E. Beecher, "On the Thoracic Legs of Trilobites": Amer. Journ. Sci. [3],