

MAPS, ETC., USED.

Geological Map of the United States, published in connection with the 9th U. S. Census, by C. H. Hitchcock and E. P. Blake.

Geological Map of New Jersey. Rept. Geol. Surv. of N. J., 1882.

Geological Map of the Vicinity of New York, by D. S. Martin.

Coast Survey Chart No. VIII. Approaches to New York. Gay Head to Cape Henlopen.

The Ancestors of the Tulip Tree (Plates LXI. and LXII. Bull. Torr. Bot. Club, Jan. 1887) by J. S. Newberry.

Flora Fossilis Arctica, Vols. VI. and VII. (Plates representing the fossil flora of the L. Atane and Patoot beds), by Oswald Heer.

United States Geological Survey, Vol. VI. (Cretaceous Flora), by Leo Lesquereux.

SPECIMENS SHOWN.

White and colored clays, pyrite nodules and lignite. Glen Cove, L. I.

Plant remains in clay. Northport, L. I.

Plant remains in sandstone, from the drift at Brooklyn, L. I.

Plant remains in concretions, from the drift near Glen Cove, L. I.

Plant remains in red shale, from clay outcrop on the shore near Glen Cove, I.

ON ANTENNÆ AND OTHER APPENDAGES OF TRI-
ARTHURUS BECKII.

BY W. D. MATTHEW.

(Plate VIII.)

Among the problems which palæontologists have in vain tried to solve was, till a few years ago, that of the structure and affinities of the trilobite. In all the vast numbers of these animals which have been found and studied, scarcely any parts have been preserved, other than the dorsal shield and hypostome. The legs, gills, etc., have practically never been shown on any specimen. This is chiefly because of the easy break afforded by the hard, smooth carapace, but, partly also, because of the character of these organs, which seem to have been soft, easily disjointed, and prone to maceration and decay. The only cases, as far as I know, in which the organs of the under side have been definitely seen and described, are three specimens of *Asaphus platycephalus* in which a number of legs are preserved

in a fragmentary way ; another of the same genus, showing a palpus attached to the hypostome, and a few cases where a detached leg or antenna was found in company with species of trilobites, and referred to one of them. Other discoveries have been reported at various times, but not conclusively verified.

It has, however, been found possible by cutting thin sections of trilobites especially well preserved in limestone, to determine the nature and position of the organs of the under side. Mr. C. D. Walcott in 1881, published the results of a very successful investigation of this kind, extending over several years, and based on the study of over 2,000 thin sections. His article has given us a very complete knowledge of the organization, at least of the two genera, *Ceraurus* and *Calymene*, which were the subjects of his study.

The structure as thus determined was :

1. A *ventral membrane* over the under side of the body, with hardened arches across each segment bearing the appendages.

2. *Cephalic limbs*. There are four pairs of these, the last of which is larger and expanded at the terminal joint into a swimming organ. The bases of these limbs were manducatory in their action.

3. *Thoracic abdominal appendages*. One pair of legs was found to be attached to each segment of the thorax and pygidium. On the basal joint of each was a small epipodite, and two branchiæ which were in the form of narrow spiral ribbons. The legs, like those of the head, were generally composed of six joints, which were more or less conical, the basal end smallest. Other forms of gills were also found, a straight uncoiled ribbon in immature specimens, and a radiating leafy form confined to the anterior part of the thorax. There is no mention of cephalic gills.

4. No trace of an *antennal system* was found.

Mr. Walcott concludes that the trilobites were more nearly allied to the Limulids than to any other living form, and should be classed with them and the Eurypterids, but as a separate subclass. As to their habits, he concludes that they probably were free swimming only when young, and crawled around on the bottom when mature.

Mr. W. S. Valiant has found a very considerable number of specimens of *Triarthrus Beckii*, in which the organs of the under side are attached to the body and fairly well preserved. They occur in the Hudson River shales* near Rome, N. Y. A number of the best specimens are now in the museum of

* Though referred to the Hudson River by Mr. Valiant, Prof. Whitfield is disposed, on palæontological grounds, to consider them as Utica shales.

Columbia College, and Prof. Kemp very kindly has given me the privilege of describing them.

The trilobites are found in a soft, fine, black shale, and are very perfectly preserved. The most noticeable character about them is the presence of long, many-jointed, rod-like attachments to the front of the head, which resemble exactly the antennæ of other crustaceans. These come out close together from just under the centre of the anterior border of the head-shield, and diverge generally at an angle of 30° or 40° . In one specimen (Fig. 1), a length considerably exceeding that of the glabella is shown*; in the rest, they are more broken, but a considerable length is preserved in three or four, and the stumps are distinctly seen in upwards of twenty others. They curve slightly outward and taper gradually down towards the end; the tip itself is not preserved. These antennæ are composed of a great number of joints, each of which is conical, about half as long as wide, and smallest at the base of the joint. (See Fig. 1^a.) As preserved, they are calcareous, but apparently of a structure less firm and thick than the substance of the carapace. Their point of origin appears to be under the front of the glabella, as they can be traced a little way under the head-shield, where they almost coalesce, then diverge and disappear; no joints are distinguishable in this part. (See Fig. 2.) Just over where they come out, the anterior rim is arched slightly upward, seemingly to give room for their play to and fro.

These organs must certainly belong to the trilobite; when attached, they are in all cases in exactly the same position, and are but rarely to be seen separate; moreover, in a number of specimens in which they were not shown, they were developed by cutting away the matrix in the proper place. Their character seems also tolerably certain, as both in position and structure they are like the antennæ of modern crustaceans. The appearance of the right hand antenna in Fig. 3, may indicate that these organs could be bent back under the sides of the shield—but this point needs more evidence.

Besides these, there are shown in several of the specimens, other appendages, some of which may be branchial in their character, and others, walking or swimming legs. In Fig. 1, the side of the head shield has been broken away, exposing the appendages, apparently of three cephalic segments. These are of two kinds, one of which seems to be a narrow, jointed,

* Mr. Vallant has since shown me a specimen which has antennæ one and a half times as long as the glabella. He informs me that there are now about sixty specimens showing antennæ.—June, 1893.

cylindrical leg, and the other is thin, broad and leafy, with what seems to be a comb-like structure similar to the gills of many crustacea. These branchiæ, if so they be, depend from a narrow, thickened anterior edge or limb; they seem to correspond with two of the three cephalic (?) legs shown in the specimen, and to overlie them. By analogy with Mr. Walcott's determinations, they are probably attached to the basal joints of the leg.

In Figs. 2, 3 and 6 are shown the ends of appendages, which projected from under the carapace, and seem to belong to the thoracic region. These are likewise of two kinds, one of which shows an oblique comb-structure or system of parallel lines (see Figs. 2, 2^a, 3 and 4); and the other is a strong tapering leg, with three cylindrical or slightly flaring joints visible (see Figs. 2, 2^a, 3, 5 and 6). The first may be a branchial appendage; it is flat and appears to broaden into a small paddle at the tip, though this appearance may be deceptive; it has a sharp ridge and narrow furrow along the anterior edge, and behind that, the series of lines or comb-like structure, which may be due, to the remains of hairs or gill-structure on the limb.

Figure 4 shows a series of appendages of both kinds, but very poorly preserved. In Fig. 7, the projecting appendages of the tail-piece are shown, and it may be seen that apparently several, and perhaps all of the pygidial limbs are anchylosed, so as to make a rounded flap, which in shape, though not in structure, reminds one of the telson of a crayfish, and perhaps served the same purpose—to propel the animal backwards through the water.

The conclusions as to the nature of these appendages are only provisional, and may be much changed by further discoveries. They are not nearly as well preserved as the antennæ, nor in so considerable a number of specimens; as besides those figured, there are only two or three others which show them at all, and those, only traces. The shape and structure of the supposed branchiæ, in particular, are very hard to distinguish; the figures given, however, represent, as far as I can see, the actual outline preserved.

It will be seen that the structure of *Triarthrus* must have differed not a little from that described by Mr. Walcott in *Calymene* and *Ceraurus*. The presence of antennæ, the broad, leafy gills, and the anchylosed flap under the pygidium (providing that the two latter are correct interpretations of the structure) are all important points of difference, and indicate that the Trilobites were quite varied in structure, and probably included a number of widely differing forms. If the classification founded on the characters of the shield is not deceptive,

we may, perhaps, consider that the structure of *Triarthrus* was that of all the *Olenidae*, the family to which it belongs; while many of the later trilobites would come nearer to *Calymene* and *Ceraurus* in their structure.

As regards the probable affinities of the trilobite, as modified by Mr. Valiant's discovery, the writer can scarcely venture any remarks, except tentatively. The homology with *Limulus* seems not to be as close in *Triarthrus* as in the forms studied by Mr. Walcott; but the characters seem to be of a more comprehensive type, approaching the general structure of the other crustacea rather than that of any special form. The presence of antennæ need not, one would think, separate them from the rest of the Pœcilopoda, for a small pair occurs in *Eurypterus*, and the anterior pair of appendages in *Limulus* are also thought to be modified antennæ. The cephalic organs are peculiar, if proved to be gills, and though in the solitary specimen showing, them they seem to belong to the head, yet further proof would be desirable, that they are not displaced, thoracic limbs. The fused pygidial flap would be a less important character, as it might easily be induced by change of conditions of life.

As regards the habits of *Triarthrus*, we may conjecture that it usually scuttled through the soft mud which composed the shale in which it is found, on the little pointed walking legs; but that it had considerable swimming powers, more, perhaps, than the later types of trilobites.

It is hardly to be expected that these antennæ, still less the other organs, will be found in specimens of trilobites unless they be exceptionally well preserved; but one character, the arching of the anterior rim at the centre of the head—if not a mere accident of preservation in these specimens—may be found to exist in less perfect fossils, and would be a fair indication of the former existence of the antennæ which passed under it.

In conclusion, I wish to acknowledge the kindness of Prof. Kemp in allowing me the honor of describing these specimens. I have also to thank Prof. Whitfield for advice and assistance in the subject, which has been very useful to me.

[NOTE.—As regards the supposed gills under the head, it would seem more probable that they were long, thickly set hairs or fimbriæ on a narrow limb, and served as mouth organs rather than gills, though, perhaps, also assisting in the respiration.—June, 1893.

May 29, 1892.

STATED MEETING.

PRESIDENT BOLTON in the chair, and fifteen persons present.

DR. MARCUS BENJAMIN read a paper entitled: "The Development of Science in New York City."

June 5, 1893.

REGULAR BUSINESS MEETING.

PRESIDENT BOLTON in the chair, and five persons present.

The following papers were read by title: "The Chorodeumidæ of North America," by O. F. Cook and F. P. Collins.

NOTE ON THE POSITION OF THE CLOACAL APERTURE IN CERTAIN BATRACHIAN TADPOLES.

BY ARTHUR WILLEY.

An interesting feature in connection with the study of Teratology is concerned with disturbances in the topographical relations of parts produced by mechanical means or, in other words, by the differential growth of neighboring structures.

One of the effects of such disturbances introduced secondarily into the life-history of an organism, is to give rise to a condition of asymmetry in the relations of this or that organ. At its first appearance, in whatever form, an asymmetrical condition must be regarded as anomalous, and we thus arrive at the paradoxical conclusion that an anomaly may, on being fixed and rendered constant by inheritance from generation to generation, become the normal state of things. This is only another way of saying that, "La tératogénie est capable de produire des espèces nouvelles." (See Paul Hallez, "Morphogénie générale et affinités des Turbellariés." Lille 1892.)

While examining recently a number of tadpoles, which were identified with the assistance of Mary H. Hinckley's paper "On Some Differences in the Mouth Structure of Tadpoles of the Anurous Batrachians found in Milton, Mass.," (Proc. Bost. Soc. Nat. Hist. XXI., 1881, pp. 307-314, Pl. V.), as the probable