29. *On CONODONTS from the CHAZY and CINCINNATI GROUP of the CAMBRO-SILURIAN, and from the HAMILTON and GENESEE-SHALE DIVISIONS of the DEVONIAN, in CANADA and the UNITED STATES.*
By GEORGE JENNINGS HINDE, Esq., F.G.S. (Read March 12, 1879.)

[PLATES XV.-XVII.]

Soon after the publication by Dr. Pander, in 1856, of his well-known monograph, in which he announced the discovery, in the lowest fossiliferous rocks of Russia, of small "teeth" named Conodonts, and referred by him to fishes, several discussions arose as to the character of these minute bodies, and various opinions were expressed as to their near relations, without, however, any satisfactory conclusion being arrived at. Since that date Conodonts have been found in several other places; and in this communication I propose to describe a great variety of forms which I have collected within the last two years from several different formations in North America. Though my specimens may not suffice to determine the true position of the organisms to which they were attached, they will at least add something to our previous knowledge, and thus assist in reaching a decision on the subject.

The next account, after Dr. Pander's, of the *discovery* of Conodonts is by Dr. J. Harley, in an article on the Ludlow bone-bed and its crustacean remains*. Only two of the specimens described by this gentleman have any resemblance to the Conodonts of Pander; but a comparison of these with other very differently formed bodies in the same beds led him to express the opinion that all the forms were of crustacean origin, and that Conodonts were probably only spines similar to those attached to the margins of the carapace of *Limulus* and the caudal segment of *Squilla*. He therefore included all together under the provisional genus *Astacoderma*.

In 1869 Mr. Charles Moore, F.G.S., discovered undoubted Conodonts in the Carboniferous Limestone of this country†; and in a late communication from that gentleman he informs me that he has them from the Silurian probably up to the Permian.

Within this last year these small bodies have been found in great variety and most beautiful preservation in Lower Carboniferous strata in Scotland by Mr. C. J. Smith, of the Eglinton Iron-works, Kilwinning, and some notes on them have been laid before the Natural-History Society of Glasgow by Mr. John Young, F.G.S. I am indebted to Mr. Young for the opportunity of looking over his specimens, and at once recognized that many of them were identical with those from the Devonian and Carboniferous formations of North America, as also with those from the same formations in Russia, figured by Pander.

* Quart. Journ. Geol. Soc. vol. xvii. p. 542 (1861).

† Report of British Association, 1869, p. 375.

Conodonts were first noticed on the American continent by Dr. Newberry, who, in the second volume of the 'Palæontology of Ohio' (1875), figured several forms and discussed their probable relations, which he believed to be rather with fishes similar to Myxinoids than with invertebrates. All Dr. Newberry's specimens were from the Lower Carboniferous at Bedford in the State of Ohio.

The oldest strata in which I have met with Conodonts are thin layers of a dark limestone belonging to the Chazy formation of the Cambro-Silurian, which, if not the equivalents, are not far separate in relative age from the green sands and black shales of Russia, the lowest beds in which these bodies have been found there. These Chazy beds are exposed on the banks of the Ottawa River at Grenville, in the province of Quebec, and are largely composed of the small tests of bivalve Crustaceans belonging to the genus *Leperditia*, associated with a few small Trilobites and Gasteropods. There are no indications of any of the larger Crustacea or Mollusca to which these Conodonts could be referred; and they are altogether too large, even if they could be referred to either of these classes of animals, to have belonged to those whose tests are here preserved. Though the Conodonts are not unfrequent in these limestones, it is somewhat remarkable that they are all of one species, and this is one of the largest of the known compound forms.

In the strata of the Cincinnati group exposed near Toronto, in which a few Conodonts appear, the rocks are principally micaceous flags and shales, and contain a great variety of fossils, Graptolites, Corals, Annelids, Brachiopods, Gasteropods, and Cephalopods of the genus *Orthoceras*, all well-known forms. No crustacean remains beyond scattered fragments of small Trilobites of the genus *Calymene* have been noticed. Whilst most of these fossils are in thin lenticular beds of limestone intervening between the flags and shales, the Conodonts are generally imbedded in the latter. In addition to a few compound teeth, there are also the simple spine-like forms of Conodonts; and it is worthy of notice that these simple forms are much more restricted in their distribution than the compound; for whilst the latter appear from the Cambro-Silurian to the Lower Carboniferous, the simple teeth are only met with, both in America and in Russia, in the Cambro-Silurian.

I have not as yet found any Conodonts in the Trenton and Utica shale rocks, which come between the Chazy and the Cincinnati group, nor in any strata of the Silurian proper and the lower division of the Devonian; but in the middle Devonian they reappear in great abundance. In strata of this age belonging to the upper beds of the Hamilton group of limestone and shales, exposed near the village of North Evans, on the south shore of Lake Erie, New York State, they are very numerous; and one particular band of limestone, which I propose to designate the Conodont-bed, is filled with fragments of these small teeth. This limestone band varies from half an inch to three inches in thickness, and may be traced for some distance. On fracture it presents a dark subcrystalline aspect, with occasional particles of a green colour, and also crystals of iron-

pyrites. In addition to the Conodonts, there are in this same bed numerous fragments of Crinoid stems, bones and plates of undetermined fishes, and teeth closely resembling, if not identical with, those of *Ptyctodus**, Pander, also from Devonian strata in Russia; but there are no remains of Crustaceans or Gasteropods. It is only on the weathered surface of the rock that Conodont teeth are visible, and then only with the assistance of a good lens.

There are also a few Conodonts associated with plates and teeth of fishes in a thin band of limestone of the Hamilton group at Arkona, Lambton County, Ontario.

Immediately succeeding the Hamilton group are beds of black bituminous shale, known as the Genesee Shale in New York and Canada, and as the Huron Shale in Ohio; and the Conodonts are distributed in these shales, in places widely apart. I have found them in exposures of these strata at Kettle Point, on the shores of Lake Huron, and at Bear Creek, both in Lambton County, Ontario, as well as in small boulders derived from these beds in the cliff-sections on the north shore of Lake Erie: at North Evans, New York, where there is a splendid section of these shales, Conodonts are also abundant; and I have also fragments from the same shales near Louisville, in Kentucky. At all these localities these shales are but sparsely fossiliferous, and the fossils are limited to spores of Lycopods and portions of other plants, a few Brachiopods of the genera *Lingula* and *Discina*, *Aviculae*, and the scales, mostly detached, of *Palæoniscus*. There are no organic fragments to give any clue to the animal to which these numerous Conodont teeth belonged.

Though my paper does not include the Lower Carboniferous Conodonts of Ohio, treated by Dr. Newberry, I may mention, from my own examination of the beds in which they occur, that the strata are black shales not dissimilar in appearance to the Genesee shales, but less bituminous; and, like these latter also, have scarcely any other organisms in addition to the Conodonts but plants and scales of Ganoid fishes.

My object in mentioning somewhat in detail the fossils occurring with the Conodonts in the different formations has been to point out that they cannot be attributed to these associated organisms, and to show the probability, so far as negative evidence extends, that these minute teeth and plates are the only portions of the animals capable of preservation in a fossil condition.

The appearance of the American Conodonts is so similar to those from Russia that Pander's description will almost equally apply to both. They occur as very minute, shining bodies, sometimes consisting of a single more or less curved conical tooth with an expanded base; but more frequently they possess an elongated basal portion in which there is generally a large tooth with rows of similar but smaller denticles on one or both sides of the larger tooth, according as this is central or at one end of the base. In some forms the

* 'Ueber die Ctenodipterinen des devonischen Systems,' St. Petersburg, 1858, p. 49, table 8.

large tooth is continued below the level of the base, forming one or more small blunted extensions; and in one of the Devonian forms this extension is greatly prolonged and also supported denticles. In other examples there is no prominent central tooth; but a series of more or less similar teeth are carried on a straight or curved base. There are also forms with a wide basal plate denticulated on the upper edge, to which, in two instances, there is an appendage attached at right angles, and apparently of different structure from the toothed basal portion. Besides these more typical examples there are other structures, not hitherto noticed, which, from their intimate connexion with the teeth, evidently belonged to the same organisms. These are minute plates of various forms, with a longitudinal ridge which, in certain cases, is extended beyond the plate and has its upper border denticulated. The plate itself is ornamented on one surface with small tubercles, whilst the other is smooth.

All these forms, though imbedded in strata of very different mechanical and chemical character, as flagstones, shales, and limestones, appear to have experienced but little alteration; they still retain their bright shining lustre, and the smooth and undisturbed outline of their bases plainly indicates that they have not been broken from the edges of the carapace of any crustacean.

The very perfect condition of the extremely minute teeth in many of the specimens also shows that they could not have been exposed to any injuries from transportation. They are all very brittle and are slowly dissolved by nitric acid. Most of the specimens are of a reddish horn-colour and translucent; very rarely do they occur of a milky white, though this white tint is the usual condition of the Ohio Carboniferous specimens, and appears to have been common in the Russian examples. Pander regarded the white specimens as belonging to older individuals; but there can be little doubt, from the occurrence of examples of both kinds of the same dimensions, that the white tint is due to some change in the chemical composition. I find the white specimens more frequently in rocks near the surface, which have been more exposed to atmospheric influences. In many specimens, particularly those occurring in the black shales, while the flat base of the compound tooth is of a reddish horn-colour and transparent, the large tooth is nearly of an ivory-white, a difference which, on microscopic examination, is seen to be due to a different structure of the tooth and base. The Conodonts from the Conodont-bed at North Evans are, as a rule, more robust and opaque and of a different lustre from those in the bituminous shales; whilst those from the Chazy limestone differ from all the rest in possessing a bright, glossy black tint.

As regards the structure of the American Conodonts, an examination of microscopic sections corroborates the result obtained by Pander from the Russian examples. I can detect the same delicate conical lamellar structure both in the specimens from the Chazy and in some of those from the Devonian; in other Devonian specimens, however, the basal portion appears to be homogeneous and without structure, whilst the teeth imbedded in this base have

either a clouded fibrous appearance, or seem to be composed of minute nuclei, as represented by Pander (Monogr. tab. 2A. figs. 11, 12).

Hitherto the Conodonts have only been found as detached specimens, scattered irregularly throughout the rock; but I have one example, from the Genesee bituminous shale, in which a group of various forms of teeth and plates have been compressed together in such a manner as to show that they must have belonged to the same animal. Unfortunately the teeth in this specimen are so crushed that nothing can be ascertained as to their natural arrangement; at the same time their numbers and variety of form show no resemblance to those of any existing animal, so that very little fresh knowledge can be gained from this specimen beyond the fact that, whatever may have been the zoological relations of the animal, it possessed a complicated and varied apparatus of teeth and plates.

I submitted my specimens to Professor Huxley, who expressed the opinion that some of them so closely resemble the teeth of the Hag-fish (*Myxine*) that it would be difficult to prove that they did not belong to fishes of this order; at the same time no living fish exhibited an assemblage of teeth and plates at all similar to those shown in the fossil example (Plate XVI. figs. 6-18).

From a microscopical examination of original specimens of Conodonts from Russia, Professor Owen states, in the first edition of his 'Palæontology,' 1870, that only those referred by Pander to the genera *Otenognathus*, *Cordylodus*, and *Gnathodus* had any probable claims to vertebrate rank, but they might also be only remains of the dentated claws of Crustacea. In the second edition of the same work, however, Professor Owen concludes that they have most analogy with the spines, or hooklets, or denticles of naked Mollusks or Annelids.

Whilst the discovery of these American Conodonts, of which some are identical with, and all generally resemble, those from corresponding rock-formations in Russia, proves the very wide distribution of these bodies, the conditions under which they appear and the fossils associated with them in America assist but little in solving the question as to their relations. In the Cambro-Silurian rocks the fossils of marine invertebrates are very varied and abundant; but there are no large Gasteropods whose lingual teeth could be supposed to be similar to Conodonts, nor the carapaces or segments of any Crustaceans to which they could have been attached as defensive spines. In the Devonian strata, where the Conodonts are much more numerous and diversified in form than in the lower rocks, the only invertebrate fossils accompanying them are Crinoids and Brachiopods; but there are here plenty of fragments of undisputed fish-teeth and bones. There is thus the same ground as in Russia for the supposition that the Conodonts were the only parts of the organism to which they were attached capable of fossilization, and that the body of the animal might have been composed of nothing more durable than the cartilaginous structures of the lower orders of fishes, or the soft tissues of Annelids and naked Mollusks. That, however, the Conodonts cannot be referred to the horny jaws

of Annelids may be conclusively shown by the discovery, by the writer, of these Annelidan structures in the same strata with Conodonts, from which the former can readily be distinguished by their chemical composition and their resemblance to the jaws of existing Annelids. Against the probability of the Conodonts having been the teeth of naked Mollusks, it may be noted that the former are principally composed of carbonate of lime, and that it is highly improbable that naked Mollusks should have abounded without any of their shell-bearing relatives having been also present (and of these in the Conodont-bearing beds of the Devonian there are no traces); nor can it be supposed that their shells can have been removed by solution when the most delicate structures of carbonate of lime have remained intact.

It has been shown that whilst Conodont teeth do not correspond in minute structure with, and are far more varied in form than, the teeth of any known fish, they yet approach closest to those of the Myxinoids. As it is not at all improbable that there was in Palæozoic times as great a development of the Cyclostome Fishes as of the Ganoids and Elasmobranchs, with a consequent great amount of variation in their structural development, we could hardly judge, from their pauperized descendants of the present day, how far this variation may have extended in former times. We should not, therefore, on account of the imperfect analogy of the Conodonts with the teeth of existing Myxinoids, reject altogether the probability that they may have belonged to a similar low type of Fishes. At present, however, the facts at hand appear insufficient to decide the question.

Owing to the uncertainty respecting the animals to which the Conodonts belonged, any arrangement of the teeth themselves must almost entirely rest on an artificial basis, and consequently possess little zoological value; detailed descriptions and figures, however, such as those given by Dr. Pander, are of great importance and service for palæontological reference; and for this purpose I have attempted to give a similar detailed account of the American forms, commencing with those from the earliest formation in which I have met with them.

1. *Conodonts from the Chazy Formation.*

Genus PRIONIODUS, Pander, 1856.

PRIONIODUS RADICANS, Hinde. (Pl. XV. figs. 1-6.)

The central tooth relatively very long and robust, and gradually tapering to a point, either straight or with a more or less dextral or sinistral curvature. The lower portion is produced below the position of the lateral denticulate extensions, to form a single blunted termination or two or three small fang-like projections. The front portion is strongly convex in section, but nearly flat at the back, and a deep longitudinal groove extends at the back of the tooth from near the tip to the base. The lateral extensions, springing more or less obliquely from both sides of the main tooth, are narrow, straight, or slightly curved, strongly convex in front and

with a groove like that of the main tooth at the back. They are frequently unequal in length and in the number of denticulations in the same specimen. These vary from 4 to 11, and are either short and blunt, or long, pointed, and slightly curved, in some cases of equal length on the same base, but frequently the central denticulations are the longest.

The teeth are smooth, black, and, where not much weathered, of a brilliant polish. The length of the central tooth varies from $\frac{1}{2}$ line to $1\frac{5}{8}$ line, the greater number are about $1\frac{1}{4}$ line. The lateral extensions vary between one third and two thirds the length of the main tooth. Though there is a great difference in form and size in these teeth, the extremes are connected by so many intermediate forms as plainly to indicate that all belong to a single species, and no other form but this appears to be present in these rocks.

This species is closely allied to *P. Volborthii*, Pander (Monogr. p. 30, tab. i. fig. 1), from which it may readily be distinguished by the basal termination and the deep longitudinal groove of the main tooth, and the proportionately less development of the lateral extensions. I am unable to make any comparison of the relative dimensions of this and Pander's species, as unfortunately no reference is made by him either to the actual size of the specimen or to the scale to which the figure is drawn.

The species is abundant and well preserved, and occurs in beds of dark limestone, principally composed of the tests of *Leperditia*.

Loc. Grenville on the Ottawa River, province of Quebec.

2. *Conodonts from the Cincinnati Group.*

Genus DREPANODUS, Pander, 1856.

DREPANODUS ARCUATUS, Pander. (Pl. XV. figs. 7, 8.)

Drepanodus arcuatus, Pander, Monographie der fossilen Fische, 1856, p. 20, tab. i. figs. 2, 4, 5.

Tooth simple, resembling a more or less curved spine, nearly circular in section, the basal portion expanded and with a slight contraction between it and the shaft of the tooth. The teeth are all translucent and of a reddish horn-colour; they vary in length from $\frac{3}{4}$ line to $1\frac{1}{8}$ line, and in width at the base from $\frac{1}{4}$ line to $\frac{3}{8}$ line.

Loc. Garrison Common, near Toronto, Ontario. Abundant.

Genus DISTACODUS*.

Machairodus, Pander, 1856.

DISTACODUS INCURVUS, Pander. (Pl. XV. fig. 9.)

Machairodus incurvus, Pander, Monographie der fossilen Fische, p. 23, tab. i. fig. 22.

Base of tooth expanded, the shaft slightly curved, the point com-

* I propose to substitute this name for Pander's *Machairodus*, the latter having been long preoccupied by Kaup.

pressed and acute; a very strongly marked broad and sharp edge on the outer curve, and a similarly sharp but narrower edge on the inner curve of the tooth; the central portion convex in section. Length $1\frac{1}{4}$ line, width of base $\frac{1}{2}$ line.

Loc. Garrison Common, near Toronto, Ontario.

PRIONIODUS ELEGANS, Pander. (Pl. XV. fig. 10.)

Prioniodus elegans, Pander, Monographie, p. 29, tab. ii. figs. 22, 23.

Basal portion straight and narrow; at the anterior extremity is an elongated tapering main tooth, the lower portion of which appears to extend below the front part of the base. On the base are thirteen straight, delicate, pointed denticles nearly uniform in size. Both main tooth and denticles convex in section. Length of main tooth $\frac{5}{8}$ line, of the horizontal base $\frac{5}{8}$ line.

My example has not the exterior denticle or the sharp edges of the main tooth of Pander's example, but in other respects it is similar. I have found but a single specimen.

Loc. Garrison Common, near Toronto, Ontario.

PRIONIODUS? POLITUS, Hinde. (Pl. XV. figs. 11, 12.)

Basal portion of tooth compressed, uneven in width, straight or slightly curved; at or near the central part a short robust main tooth with a series of short compressed denticles, varying from five to eight in number, on either side of it. Length of base from $\frac{1}{2}$ line to $\frac{3}{4}$ line. The specimens have a bright polished appearance and a light horny tint.

Loc. Garrison Common and Don valley, near Toronto, Ontario.

PRIONIODUS FURCATUS, Hinde. (Pl. XV. fig. 13.)

Base narrow and strongly arched, at the centre of the arch a prominent robust main tooth, slightly curved, depressed convex, and with sharp edges, the lower extremity blunted and produced beyond the base. On one side of the central tooth the base carries six flattened denticles inclined to the centre; on the other side are eight similar denticles, but vertical to the base. Length of main tooth $\frac{3}{8}$ line; distance between the extremities of the base $\frac{5}{8}$ line.

The strongly arched form, the prominence of the main tooth, and its extension below the base distinguish this from the foregoing species.

Loc. Garrison Common, near Toronto, Ontario.

Remarks on the Cambro-Silurian Conodonts.

It is worthy of notice that of the six species above described no fewer than three should be identical with, and the other three should have a close general resemblance to, the forms discovered by Pander near St. Petersburg. At the same time there is by no means the same proportion in respect to the number of the species of the simple and compound teeth found in the two countries; for whilst there is nearly an equal number of the compound forms in the Cambro-Silurian of Canada as of Russia, only two species of the simple teeth

have as yet been found in Canada; but in Russia these simple teeth abound in such great variety that Pander divided them into no fewer than seven genera, including thirty-eight species. It is also remarkable that neither in Canada nor in Russia do these *simple* teeth appear to extend to a higher geological horizon, though the *compound* ones in the lower rocks have a generic resemblance to those from the Devonian and Carboniferous. There is the still further coincidence that in Russia only traces, and in Canada none, of these bodies have as yet been met with in strata between the Cambro-Silurian and the Devonian; but a further special search may lead to their discovery in the intermediate rocks.

3. *Conodonts from the Hamilton and Genesee-Shale divisions of the Devonian.*

In certain beds of these Devonian rocks the Conodonts appear in such profusion and variety of form as far to surpass those already described from the Siluro-Cambrian; and, judging from Pander's description, they are more numerous and better-preserved than those in the Devonian and Carboniferous rocks of Russia. The work of classifying these various forms has to some extent been simplified by the discovery of the specimen, already mentioned, in which a number of diversely shaped teeth, together with small plates, are shown to have appertained to the same individual, which I describe below under the generic name of *Polygnathus*. A good proportion of the other detached teeth in the same rocks are related to those of *Polygnathus*, and, for the sake of reference, will have to be described separately, though, judging from the remarkable combination of various forms in this individual, all these teeth may have belonged to two or three species only. There are, however, in this type specimen of *Polygnathus* none of the more typical forms of *Prioniodus* with a very prominent elongated central or terminal main tooth, so that I purpose to retain this genus for similar forms. As an indication of the uncertainty attending the classification of these teeth from detached specimens, I may mention that in the individual example of *Polygnathus* there are teeth which Pander has placed under different genera.

PRIONIODUS ERRATICUS, Hinde. (Pl. XV. fig. 14.)

Tooth with a short, narrow, slightly arched base, at one extremity of which a relatively large, cylindrical, slightly curved main tooth projects obliquely outwards, forming an obtuse angle with the base. On the base are five stout, nearly upright, smaller teeth or denticles, which in some specimens are more elongated than in the one figured.

Locality and Formations. North Evans, New York State: from the "Conodont-bed" of the Hamilton group. Also from Bedford, Ohio: in the Cleveland Shales of the Lower Carboniferous.

PRIONIODUS ABBREVIATUS, Hinde. (Pl. XV. fig. 15.)

Base of tooth very short and stout, at one end a comparatively

long, nearly straight, cylindrical, blunted, main tooth, on one side of which are two blunted denticles with small knobs at their summits. Length of main tooth $\frac{5}{8}$ line, of the base $\frac{1}{4}$ line.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group.

PRIONIODUS CLAVATUS, Hinde. (Pl. XV. fig. 16.)

Basal portion arched, narrow, stout and convex in section; the central tooth straight, cylindrical, and blunted; on one side of this there are four, and on the other two stout teeth similar to the central tooth and but little inferior in size.

Length of base $\frac{5}{8}$ line, of the central tooth $\frac{1}{2}$ line.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group.

PRIONIODUS ANGULATUS, Hinde. (Pl. XV. fig. 17.)

Base thin, narrow, and arched, so that the two sides meet at an acute angle; from the apex there rises a long, straight, compressed, needle-shaped main tooth with a median longitudinal groove; on either side of the base are four slightly curved slender denticles. Distance between extremities of the base $\frac{1}{2}$ line; length of main tooth $\frac{1}{2}$ line. This species is very delicate and brittle, and perfect examples are rare. The missing portions, however, leave their impressions in the shale, so that the entire form can be readily distinguished.

Loc. North Evans, New York: from Genesee Shale. Also at Bedford, Ohio: in Cleveland Shales, Lower Carboniferous.

PRIONIODUS ACICULARIS, Hinde. (Pl. XV. figs. 18, 19.)

Basal portion straight or slightly arched, generally wide, very thin, polished and transparent; near one extremity a relatively large, slightly curved, compressed main tooth, with two denticles on one side, and on the other a series of from eleven to thirteen delicate, slightly curved, acutely pointed denticles, slightly inclined to the base in which they are imbedded. The main tooth and the denticles have a polished aspect and tint like ivory, whilst the base is of a brownish horn-colour. In fig. 18 the length of the base is $\frac{7}{8}$ line, and of the main tooth $\frac{5}{8}$ line; in fig. 19 the base is 1 line and the main tooth $\frac{7}{8}$ line in length.

The base is very variable in width in different examples, and in some forms the two denticles preceding the main tooth are not present.

Loc. Kettle Point and Bear Creek, Lambton County, Ontario; North Evans, New York: Genesee Shale.

PRIONIODUS ARMATUS, Hinde. (Pl. XV. figs. 20, 21.)

Basal portion very narrow and slightly curved; at one extremity a relatively large, triangular, depressed convex main tooth, the exterior basal angle of which is produced downwards into a short spur. There are from five to eleven straight compressed denticles. Length of base from $\frac{1}{2}$ line to $\frac{3}{4}$ line, of the main tooth $\frac{5}{8}$ line.

Loc. Near Port Stanley, Lake Erie, Ontario: in erratic boulders

of Genesee Shale. Also from North Evans, New York, in Genesee Shale.

PRIONIODUS SPICATUS, Hinde. (Pl. XVI. figs. 1, 2, 3.)

Basal portion straight, narrow, and convex; at one extremity a straight or slightly curved main tooth which is produced below the horizontal base to a pointed projection. A variable number of straight slender denticles are present on the base, and between these are intercalated still smaller denticles. Length of base $\frac{3}{4}$ line, of main tooth $\frac{1}{2}$ line to $\frac{5}{8}$ line.

Loc. Bear Creek, Ontario; North Evans, New York: Genesee Shale.

PRIONIODUS PANDERI, Hinde. (Pl. XVI. fig. 4.)

A relatively very large, slightly curved, depressed convex main tooth springs from one extremity of the narrow horizontal base; attached to the base of the main tooth, and extending downwards, is a prominent spike-like projection, which has on its upper surface the bases of what appear to have been four stout denticles; on the horizontal base are the lower portions of six denticles. Length of the large tooth $1\frac{1}{8}$ line, of the projection $\frac{1}{2}$ line, and of the base $\frac{7}{8}$ line.

This species is allied to *P. tulensis*, Pander (Monograph. p. 30, tab. 2A. fig. 19) which has also a somewhat similar produced spike below the main tooth, with a single denticle on it. *P. tulensis* is from the Carboniferous Limestone in the province of Tula, Russia.

I have named this species in memory of Dr. Pander, the first discoverer of Conodonts.

Loc. Kettle Point, Ontario: Genesee Shale. Also from North Evans, New York: in the "Conodont-bed" of the Hamilton group.

PRIONIODUS? *ALATUS*, Hinde. (Pl. XVI. fig. 5.)

A comparatively large, triangular, depressed convex main tooth with a narrow arched base, one arm of which is produced obliquely downwards and carries five, short, blunted denticulations on the exterior edge. This tooth varies greatly from the more typical forms of *Prioniodus*, in its triangular form and in having the basal portion but very indistinctly marked off from the tooth itself; the smaller denticulations have also the appearance of being only prolongations of the thin border of the main tooth. Length $1\frac{7}{8}$ line, greatest width $\frac{3}{4}$ line.

Loc. North Evans, New York: in the "Conodont-bed" of the Hamilton group.

Genus *POLYGNATHUS*, Hinde, nov. gen.

I propose this genus for an animal possessing numerous minute and variously formed Conodont teeth and similarly minute tuberculated plates grouped together, but of which the natural arrangement is not at present known.

This meagre definition is all that is afforded by the single example of the genus met with, in which about twenty-four entire and frag-

mentary teeth and six plates have been crushed together in a small patch of about one fourth of an inch in diameter, in black shale. The specimen was discovered in splitting open a slab of the rock, the division taking place in the centre of the specimen. No indication can be seen of the natural position of the teeth and plates; but it can hardly be doubted that they all belonged to one individual, as it would be beyond all reasonable probability that so many diversely formed teeth, of such delicate structure, could have been thus brought together into so small a space by mechanical means, more particularly when it is a very rare circumstance to find, in the same rock, even two detached teeth at all close together; and in only one other instance have I found two Conodonts partially connected together, and these are forms which are present in this compound example. If, however, these various teeth and plates were attached in their natural positions by soft tissues merely, by the decay of these they would be liable to be crushed together into a shapeless mass like that presented by the specimen.

POLYGNATHUS DUBIUS, Hinde. (Pl. XVI. figs. 6-18.)

The only example discovered in which the teeth of this remarkable form are grouped together has been crushed to such an extent that the individual teeth and plates can be only partially distinguished; but the various kinds are met with in a very perfect condition, as so many separate specimens, scattered through the rock. As these detached teeth occur not only in the rock in which the grouped specimen is found, but are widely distributed even in Lower Carboniferous rocks, I append descriptions and figures of the individual teeth and plates.

For the convenience of reference I refer the teeth to pectinate, fimbriate, and crested forms.

1. *Pectinate teeth*.—Of these the kind figured in Pl. XVI. figs. 6-9 has a narrow, slightly arched base and a main tooth which is sometimes produced below the level of the base; the secondary teeth are slender and acute, and vary from 14 to 20 in number. This kind averages about $\frac{3}{4}$ line in length, and is abundant in the "Conodont-bed" of the Hamilton group as well as in the Genesee Shale at North Evans.

Another variety of pectinate compound teeth, shown in Pl. XVI. figs. 10, 11, 12, has the base straight and almost linear; there is no distinctive central tooth, but a series of similarly shaped teeth, sometimes as many as 14, of which the central ones are the longest. Occasionally smaller denticles are intercalated. The base of these forms is about $\frac{3}{4}$ line in length, and the longest teeth from $\frac{3}{8}$ to $\frac{1}{2}$ line long. This variety is very widely distributed. It has been described by Pander under the name of *Centroodus simplex* ('Monograph,' p. 31, tab. 2A. figs. 2, 3, 5, 6), from the Lower Carboniferous in Russia; it occurs in the same formation at Bedford, Ohio, and also appears in Genesee Shale at Kettle Point, Ontario, as well as at North Evans, New York.

2. *Fimbriate teeth* (Pl. XVI. figs. 13, 14).—The base of these com-

pound teeth is straight, narrow, elongate, and pointed at one extremity; near the opposite end is a delicate, needle-like main tooth with three smaller teeth on one side between it and the end of the base; on the other side, extending to the pointed tip of the base, is a series of very numerous, extremely minute denticles, appearing like a fringe on the upper border of the base. In some examples these small denticles are nearly uniform in size, in others every fourth tooth is larger; but there exists considerable variation in this respect, even in the same specimen. In the example figured (fig. 13), of which the base is $1\frac{1}{5}$ line in length, there are 70 of the small denticles. This form is very abundant and quite as widely distributed as the preceding. It appears to be identical with the fragmentary tooth named by Pander *Centrodus lineatus* ('Monographie,' p. 31, tab. 2 A. fig. 9), from the Lower Carboniferous in Russia; it is in the same formation at Bedford, Ohio, and is also found at Kettle Point and Bear Creek, Ontario, and at North Evans, New York, in the Genesee Shale.

* 3. *Crested teeth* (Pl. XVI. figs. 15, 16, 17).—Of these there are two varieties present in *Polygnathus dubius*. The first (fig. 15) has the base compressed and nearly of equal width, save at one end, which is abruptly contracted. There are about twenty small teeth or crenulations on the base. The second variety (figs. 16, 17) has one part of the base narrow and thickened, with sometimes a row of minute crenulations on its upper edge; beyond this the base forms a small, flattened, crest-like expansion with from 5 to 8 teeth on its border. Both these varieties are closely allied to the form named by Pander *Gnathodus mosquensis* ('Monographie,' p. 24, tab. 2 A. figs. 10 a, b, c). The second is the more abundant of the two, and three or four individuals can be distinguished in the crushed example of *Polygnathus*.

The small plates associated with the teeth in *Polygnathus dubius* are of an elliptical form with smooth edges (Pl. XVI. fig. 18). One surface is slightly convex, with a slight longitudinal median ridge; the surface, as well as the ridge, is covered with small tubercles frequently with a linear arrangement; the reverse side of the plate is smooth, with faint traces of concentric lines; the two ends are slightly elevated, and there is a median ridge with a small diamond-shaped pit in or near the centre of the plate. Each plate is about $\frac{2}{3}$ line long and $\frac{2}{3}$ line wide. Six of these plates, but all apparently of the same form, can be distinguished in the specimen of *Polygnathus*.

Besides the teeth already referred to, there are fragments of others too imperfect to be recognized, and these may possibly belong to some forms which, occurring as detached specimens, I have described under other names.

The existence of such a variety of teeth and plates in this single example appears to make the question of the affinities of the organism to which they belonged still more complex. Great numbers of teeth compose the lingual ribbon of many mollusks; but in none, that I am aware of, is there a similar variety of form, nor are there any bodies analogous to the tuberculated plates. Nor in existing Myxinoidea, to whose teeth the Conodonts are comparable, are similar

plates present. Whatever the animal may have been, it appears to have had a very wide distribution both in Devonian and Carboniferous times.

Locality and Formation. The single specimen, in which the above-mentioned teeth and plates are shown together, is from the Genesee Shale (Devonian) at North Evans, N.Y.

POLYGNATHUS DUPLICATUS, Hinde. (Pl. XVI. fig. 19.)

Base of the compound tooth bent at an obtuse angle, narrow, and slightly convex; in the centre a needle-like tooth oblique to the base, with a similar but slightly shorter tooth adjacent to it; this is followed by six acute denticles on one side of the base, and on the opposite side are eleven very small denticles nearly at right angles to the base. Length of base $\frac{5}{8}$ line.

This form is closely allied to some of the pectinate teeth of *P. dubius* and may belong to a mere variety of that species. The detached position of this and the forms described below makes it a necessity to place them under different names, though there is great probability that they do not belong to more than one or two species.

Loc. Bear Creek, Ontario: Genesee Shale.

POLYGNATHUS RADIATUS, Hinde. (Pl. XVI. fig. 20.)

Tooth very minute; the base curved, narrow, and compressed in the centre; a broad, slightly convex, main tooth inclined to the base; on one side of this there are six, and on the other four flattened, curved denticles. Length of base $\frac{1}{2}$ line.

Loc. Kettle Point, Ontario: Genesee Shale.

POLYGNATHUS IMMERSUS, Hinde. (Pl. XVI. fig. 21.)

Tooth minute; base slightly curved and very wide; nearly in the centre is a short, blunted, main tooth, on one side of which there are ten, and on the other eight very delicate, elongated denticles. All these teeth are so deeply imbedded in the delicate transparent base that only the tips project beyond it. Length of base $\frac{5}{8}$ line, of the main tooth $\frac{1}{4}$ line.

This form closely resembles *Otenognathus Verneuxi*, Pander, from the Devonian of Russia ('Monographie,' p. 32, tab. 2A. fig. 16).

Loc. Kettle Point, and in erratic boulders on the north shores of Lake Erie, Ontario: Genesee Shale.

POLYGNATHUS NASUTUS, Hinde. (Pl. XVI. fig. 22.)

Base of tooth narrow, elongated, and straight, terminated at one end by a broad, flattened, depressed main tooth, which projects in a line with the base; below the main tooth, and making an acute angle with the base, is a small arm carrying three denticles; on the base itself are twenty denticles of various lengths. Length of base $1\frac{1}{8}$ line.

Loc. North Evans, New York: Genesee Shale.

POLYGNATHUS PRINCEPS, Hinde. (Pl. XVI. fig. 23.)

On a narrow, elongated base there is a series of eleven relatively large and robust teeth, somewhat oval in section. The central teeth are larger than those near the extremities of the base. Length of base 2 lines, of the largest tooth $\frac{5}{8}$ line. *Centroodus simplex*, Pander ('Monographie,' p. 31, tab. 2A. fig. 3), seems to be a fragment of a similarly large tooth from the Carboniferous of Russia.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group and the Genesee Shale.

POLYGNATHUS CORONATUS, Hinde. (Pl. XVII. fig. 1.)

Base very narrow and gracefully arched, with seven subequal, relatively large, robust, curved teeth. The teeth in this form are of an ivory-white, whilst the base is brownish and translucent. It is closely allied to *Centroodus convexus*, Pander ('Monographie,' p. 31, tab. 2A. fig. 4); but has a narrower base, more teeth, and no intercalated small ones. Length of base $\frac{3}{4}$ line, of the longest tooth $\frac{5}{8}$ line.

Loc. Kettle Point, and in erratic boulders on north shore of Lake Erie, Ontario: Genesee Shale.

POLYGNATHUS SOLIDUS, Hinde. (Pl. XVII. fig. 2.)

On a short, very thick, and wide base there is a closely arranged series, varying from seven to eleven in number, of subequal, short, stout and obtuse teeth. Very abundant.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group.

POLYGNATHUS CRASSUS, Hinde. (Pl. XVII. fig. 3.)

Base of tooth narrow, curved, and relatively very thick, with a prominent ridge, in which are six obtuse teeth or crenulations; the posterior extremity crest-like, with two stout teeth on the summit. Length $\frac{5}{8}$ line.

This form is allied to the crested teeth of *P. dubius*; but it is a shorter and more robust form.

Loc. North Evans, New York: "Conodont-bed" of the Hamilton group.

POLYGNATHUS? SERRATUS, Hinde. (Pl. XVII. figs. 4 & 5.)

Tooth or jaw formed of a thin, curved, and highly convex basal plate, truncated at one end, and with a blunt projection at the opposite extremity. On the upper edge are about thirty minute crenulations or blunted teeth. Length 1 line, width $\frac{3}{8}$ line.

This species and the two following differ from the more typical forms of Conodonts; but as they appear to be connected with the "crested" teeth of *P. dubius*, I place them provisionally under that genus. They have also a resemblance to *Gnathodus mosquensis*, Pander ('Monographie,' p. 33, tab. 2A. figs. 10 a, b, c). *P. ? serratus* appears at present only in one place, where, however, it is abundant.

Loc. Kettle Point, Ontario: Genesee Shale.

POLYGNATHUS? *ERIENSIS*, Hinde. (Pl. XVII. fig. 6.)

Tooth or jaw formed of an oblong, compressed plate, with ten stout, blunt teeth on its upper border. This plate is attached nearly at right angles to a chitinous appendage, nearly of a triangular form, whilst the toothed portion of the jaw is of the usual brownish semi-translucent character common to the majority of the Conodonts; the appendage has a black chitinous appearance. Length $1\frac{1}{2}$ line.

Loc. From an erratic nodule of black Genesee Shale on north shore of Lake Erie, Ontario.

POLYGNATHUS? *CURVATUS*, Hinde. (Pl. XVII. fig. 7.)

Tooth or jaw formed of a wide, oblong, slightly curved plate with about fourteen blunt teeth or crenulations on the upper border; this plate is attached at right angles to a compressed, sickle-shaped, grooved appendage of a similar structure to that of the preceding species, from which, however, it differs in shape. Length $1\frac{1}{4}$ line.

I have only met with a single specimen.

Loc. Bear Creek, Ontario: Genesee Shale.

POLYGNATHUS *PENNATUS*, Hinde. (Pl. XVII. fig. 8.)

An elongated oval plate with a longitudinal depressed furrow, in the centre of which rises a slender keel, which is produced beyond the main portion of the plate and has a few blunt tubercles on its crest. Transverse ridges run from the outer edge of the plate to the central furrow. Abundant.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group.

POLYGNATHUS *TUBERCULATUS*, Hinde. (Pl. XVII. figs. 9 & 10.)

Plate somewhat circular in outline, with a prominent central keel produced and tuberculated; in the lower portion of the plate is a partially detached lobe on either side of the central line; the plate is provided with rows of tubercles which converge towards the centre. The reverse side of a form which appears to belong to this species (fig. 10) has a central ridge with a small diamond-shaped pit just below the centre of the plate; the surface of this reverse side is smooth, with traces of concentric lines. Length of plate and keel $\frac{7}{8}$ line, and $\frac{1}{2}$ line in width.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group.

POLYGNATHUS *CRISTATUS*, Hinde. (Pl. XVII. fig. 11.)

Plate oval in outline, depressed, convex; the central keel very prominent and with stout teeth or crenulations on its crest; on the plate are two rows, on either side of the central keel, of prominent tubercles. Length $\frac{7}{8}$ line, width $\frac{1}{2}$ line.

Loc. North Evans, New York: from the "Conodont-bed."

POLYGNATHUS *TRUNCATUS*, Hinde. (Pl. XVII. figs. 12 & 13.)

Plate cordate in outline, with a median keel which is not continued

beyond the plate; the convex surface covered with small tubercles. Length $\frac{1}{2}$ line. A variety of this form (fig. 13) appears to have no keel whatever, but a simple tuberculated surface.

Loc. Bear Creek, Ontario: from the Genesee Shale. Also from North Evans, New York: from the "Conodont-bed" of the Hamilton group.

POLYGNATHUS PUNCTATUS, Hinde. (Pl. XVII. fig. 14.)

Plate unsymmetrical, flat and thin; a delicate keel which does not reach to the tip, but is produced beyond the lower portion of the plate and has two or three nodes on it; the surface of the plate is covered with very minute tubercles. Length $\frac{5}{8}$ line.

Loc. North Evans, New York: Genesee Shale.

POLYGNATHUS LINGUIFORMIS, Hinde. (Pl. XVII. fig. 15.)

Plate elongate, one extremity produced into a tongue-like projection, bending downwards; the sides of the plate curving upwards, forming a central trough, from the bottom of which the keel rises, this extends some distance beyond the sides of the plate and has an expanded crenulated crest. The anterior tongue-like projection has several strongly-marked transverse ridges; the lateral surfaces have a few scattered tubercles. Length about 1 line. This peculiar form is very abundant.

Loc. North Evans, New York: from the Conodont-bed of the Hamilton group. Also in erratic boulders in Genesee Shale on north shore of Lake Erie, Ontario.

POLYGNATHUS PALMATUS, Hinde. (Pl. XVII. figs. 16 & 17.)

Plates elongated, with an unsymmetrical, partially lobed outline, depressed in the central portion, a longitudinal keel, and sometimes a delicate transverse one, extending from one side only to the central depression; surface smooth and polished and with traces of concentric lines; the reverse side of this form also appears to be smooth. Length varying from $\frac{5}{8}$ line to $1\frac{1}{8}$ line, and width between $\frac{1}{2}$ line and $\frac{7}{8}$ line.

In the smooth surface and very irregular outline this differs from all the preceding varieties of these plates. This form is very abundant and widely distributed.

Loc. Kettle Point, Bear Creek, Ontario; North Evans, New York; near Louisville, Kentucky: Genesee Shale.

POLYGNATHUS ? SIMPLEX, Hinde. (Pl. XVII. fig. 18.)

Jaw? resembling a tenter-hook in shape and nearly oval in section; the proximal extremity is smooth and rounded like that of an articular surface; a prominent ridge extends in a median line from this end to near the tip of the hook; the surface of the jaw above this ridge is smooth and glistening, whilst below it very fine parallel

lines can be seen. Length of the straight portion $\frac{5}{8}$ line, of the hook $\frac{1}{4}$ line.

These small shining bodies are very abundant in the same beds with the Conodont teeth and plates, and though diverse in form, they correspond in apparent structure and relative dimensions; therefore I regard them as related to the same organisms, and place them provisionally under the same genus with the equally problematical plates and teeth.

Loc. North Evans, New York: from the "Conodont-bed" of the Hamilton group.

EXPLANATION OF THE PLATES.

PLATE XV.

- Figs. 1-6. *Prioniodus radicans*, H. Figs. 2, 3, 4, 5 are front views; fig. 1 and 6 show the reverse side with the longitudinal groove: $\times 10$. Grenville, Province Quebec. (Chazy.)
- 7, 8. *Drepanodus arcuatus*, Pander: $\times 10$. Toronto. (Cincinnati.)
9. *Distacodus incurvus*, Pander: $\times 10$. Toronto. (Cincinnati.)
10. *Prioniodus elegans*, Pander: $\times 20$. Toronto. (Cincinnati.)
- 11, 12. —? *politus*, H.: $\times 20$. Toronto. (Cincinnati.)
13. — *furcatus*, H.: $\times 20$. Toronto. (Cincinnati.)
14. — *erraticus*, H.: $\times 20$. North Evans, N.Y. (Hamilton and Carboniferous.)
15. — *abbreviatus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
16. — *clavatus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
17. — *angulatus*, H.: $\times 20$. North Evans, N.Y. (Genesee and Carboniferous.)
- 18, 19. — *acicularis*, H.: $\times 20$. Kettle Point, Ontario. (Genesee.)
- 20, 21. — *armatus*, H.: $\times 20$. North Evans, N.Y. (Genesee.)

PLATE XVI.

- Figs. 1, 2, 3. *Prioniodus spicatus*, H.: $\times 20$. North Evans, N.Y. (Genesee.)
4. — *Panderi*, H.: $\times 20$. North Evans, N.Y. (Genesee and Hamilton.)
5. —? *alatus*, H.: $\times 10$. North Evans, N.Y. (Hamilton.)
- 6-18. *Polygnathus dubius*, H.: $\times 20$. Figs. 6-12 represent different forms of pectinate teeth; figs. 13 and 14 fimbriate teeth; figs. 15, 16, 17 crested teeth; and fig. 18 shows the reverse side of one of the plates of this species. Kettle Point, Ontario; North Evans, N.Y.; and Bedford, Ohio. (Hamilton, Genesee, and Carboniferous.)
19. — *duplicatus*, H.: $\times 20$. Bear Creek, Ontario. (Genesee.)
20. — *radiatus*, H.: $\times 20$. Kettle Point, Ontario. (Genesee.)
21. — *immersus*, H.: $\times 20$. Kettle Point, Ontario. (Genesee.)
22. — *nasutus*, H.: $\times 20$. North Evans, N.Y. (Genesee.)
23. — *princeps*, H.: $\times 20$. North Evans, N.Y. (Genesee and Hamilton.)

PLATE XVII.

- Fig. 1. *Polygnathus coronatus*, H.: $\times 20$. Kettle Point, Ontario. (Genesee.)
2. — *solidus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
3. — *crassus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
- 4, 5. —? *serratus*, H.: $\times 20$. Kettle Point, Ontario. (Genesee.)

Fig. 6. *Polygnathus? eriensis*, H.: $\times 20$. Lake Erie shore, Ontario.
(Genesee.)

7. — *? curvatus*, H.: $\times 20$. Bear Creek, Ontario. (Genesee.)
8. — *pennatus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
- 9, 10. — *tuberculatus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
11. — *cristatus*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)
12. — *truncatus*, H.: $\times 20$. Bear Creek, Ontario. (Genesee.)
13. — *truncatus*, var.: $\times 20$. North Evans, N.Y. (Hamilton.)
14. — *punctatus*, H.: $\times 20$. North Evans, N.Y. (Genesee.)
15. — *linguiformis*, H.: $\times 20$. North Evans, N.Y. (Hamilton and Genesee.)
- 16, 17. — *palmatus*, H.: $\times 20$. Kettle Point, Ontario. (Genesee.)
18. — *? simplex*, H.: $\times 20$. North Evans, N.Y. (Hamilton.)

(For Discussion on this paper, see p. 389.)

CONODONTS.
Mintern Bros lith.

CONODONTS.
Mintern Bros lith.

CONODONTS.
Münster-Brosilith.