

MEMOIRS  
OF THE  
GEOLOGICAL SURVEY  
OF  
THE UNITED KINGDOM.

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*Figures and Descriptions*

ILLUSTRATIVE OF  
BRITISH ORGANIC REMAINS.

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MONOGRAPH II.

ACCOMPANIED BY THREE FOLIO PLATES.

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## BRITISH FOSSILS.

On the STRUCTURE of the BELEMNITIDÆ; with a description of a more complete Specimen of *Belemnites* than any hitherto known, and an account of a New Genus of BELEMNITIDÆ, *Xiphoteuthis*, by THOMAS H. HUXLEY, F.R.S., Professor of Natural History, Royal School of Mines.

THE fossil shell called *Belemnites* consists fundamentally of (1) a hollow cone, the *phragmoconus*, with a thin, shelly, wall which may be termed the *conothea*, and which is divided by transverse *septa*, more or less convex towards the apex of the cone, and concave towards its base, into chambers, or *loculi*. Each septum is traversed, close to the *conothea*, in a direction which corresponds with the median ventral line of the body, by a canal, the *siphunculus*. More or less extensively enveloping the apical part of the phragmocone is (2) a more solid body, the guard, or *rostrum*, composed of calcareous matter arranged in prisms, or fibres, perpendicular to the planes of lamellæ. These are disposed concentrically around an axis, the so-called *apical line*, which extends from the extremity of the phragmocone to that of the rostrum.

All observers are agreed as to the presence of the parts hitherto mentioned in a Belemnite, but a great diversity of opinion prevails respecting the nature, and indeed the existence, of a third constituent of the fossil, the so-called "pen" or "osselet." As the part which commonly goes by the name of "pen" in the Belemnite, however, corresponds to only a part of the structure already known as the "pen" in recent *Cephalopoda*, I shall endeavour to avoid ambiguity, by using for it the appellation of *pro-ostracum*.

In a paper "On the discovery of a new species of Pterodactyle, and also of the fæces of the Ichthyosaurus, and of a black substance resembling Sepia or Indian ink, in the Lias of Lyme Regis," read before the Geological Society, on the 6th February 1829, by Dr. Buckland, the following passage occurs.

"3. *Fossil Sepia*.—An indurated black animal substance, like that in the ink-bag of the cuttle fish, occurs in the Lias at Lyme Regis: and a drawing made with this fossil pigment, three years ago, was pronounced by an eminent artist to have been tinted with sepia. It is nearly of the colour and consistence of jet, and very fragile, with a bright splintery fracture; its powder is brown, like that of painters' sepia; it occurs in single masses, nearly of the shape and size of a small gall-bladder, broadest at the base, and gradually contracted towards the neck: these are always surrounded by a thin nacreous case, brilliant as the most vivid Lumachella; the nacre seems to have formed the lining of a fibrous, thin, shelly substance, which, together with this nacreous lining, was prolonged into a hollow cone like that of a belemnite, beyond the neck of the ink-bag; close

to the base of the ink-bag there is a series of circular transverse plates and narrow chambers, resembling the chambered alveolus within the cone of a belemnite ; but, beyond the apex of this alveolus, no spathose body has been found.

“ The author infers that the animal from which these fossil ink-bags are derived, was some unknown cephalopod, nearly allied in its internal structure to the inhabitant of the belemnite ; the circular form of the septa showing that they cannot be referred to the molluscous inhabitant of any nautilus or cornu-ammonis.”

This is, so far as I am aware, the first notice of the existence of a pro-ostracum in a Belemnite.

Voltz, writing in 1830, had no direct knowledge of the existence of any such structure, though he was led by observation of the lines of growth of the conotheca, to conclude that it was prolonged dorsally ; but, in the same year, Count Münster\* published descriptions and figures of *Belemnites* with complete pro-ostraca.

“ In the Belemnites there is an empty prolongation, similar to the last open chamber, of the guard, which is as long as the thick and chambered shell, but infinitely more delicate, as in the Orthoceratites, and hardly of the thickness of the skin of a bladder.”

The species which exhibited this pen in the best state of preservation was *Belemnites semisulcatus*, complete specimens of which, from the Solenhofen slates, are represented in Count Münster's third and fourth figures.

Dr. Buckland returns to the subject in his “ Bridgewater Treatise ” (1836), page 374, note.

“ In 1829, I communicated to the Geological Society of London a notice respecting the probable connection of Belemnites with certain fossil ink-bags, surrounded by brilliant nacre, found in the Lias at Lyme Regis. (See Phil. Mag., N.S., 1829, p. 388.) At the same time I caused to be prepared the drawings of fossils engraved in Plate 44”, which induced me to consider these ink-bags as derived from Cephalopods connected with Belemnites. I then withheld their publication, in the hope of discovering *certain* demonstration, in some specimens that should present these ink-bags in connection with the sheath or body of a Belemnite, and this demonstration has at length been furnished by a discovery made by Professor Agassiz (October 1834), in the cabinet of Miss Philpotts, at Lyme Regis, of two important specimens which appear to be decisive of the question. (See Pl. 44', figs. 7-9.

“ Each of these specimens contains an ink-bag within the anterior portion of the sheath of a perfect Belemnite ; and we are henceforth enabled with certainty to refer all species of Belemnites to a family in the class of Cephalopods for which I would, in concurrence with M. Agassiz, propose the name of *Belemnosepia*.† Such ink-bags are

\* “ Nouvelles Observations sur les Bélemnites, in Boué's Mémoires Géologiques,” translated from “ Bemerkungen zur näheren Kenntniss der Belemniten.”—4to. Baireuth, 1850, p. 296.

† Buckland it is obvious, proposes *Belemnosepia* as a name for the animal, or ‘ family ’ of animals to which the shell called “ Belemnite ” belongs, and not as a name for the particular specimens which he examined. Those who have considered these specimens not to belong to the family of the *Belemnitidæ* at all, therefore, but to the *Teuthidæ* or *Loligidæ*, are not justified in using *Belemnosepia* as a generic title—for the intention of the authors of that name is to employ *Belemnosepia* as the equivalent of *Belemnites* in its ordinary acceptation ; and as naturalists have refused to do so, and continue, as I think, wisely, to use “ *Belemnites* ” for the genus of animals which fabricate the shell called “ Belemnite,” *Belemnosepia* remains as a mere synonym, and can be employed in no other sense.

occasionally found in contact with traces of isolated alveoli of Belemnites; they are more frequently surrounded only by a thin plate of brilliant nacre."

In his statement of the component parts of a Belemnite (l. c., p. 372), Dr. Buckland very clearly defines the characters of the part which he had discovered; it is, says he, "a conical, thin, horny sheath or cup, commencing from the base of the hollow cone of the fibro-calcareous sheath, and enlarging rapidly as it extends outwards to a considerable distance. Pl. 44', fig. 7 b, e, e', e'". This horny cup forms the anterior chamber of the Belemnite, and contained the ink-bag (c) and some other viscera."

In Dr. Buckland's restoration of the "Belemnosepia," Pl. 44' fig. 1, the cup in question, or pro-ostracum, e, e, is made to extend nearly to the anterior end of the mantle of the animal.

In the preceding year (1835) Professor Agassiz communicated a short note, "Ueber Belemniten," to Leonhard and Bronn's "Jahrbuch," in which he states that "he has made out with certainty that the so-called *Onychoteuthis prisca* with the ink-bags, as they are figured by Van Zieten (as *Loligo*, Tab. XXV.), are nothing but the anterior prolongation of a Belemnite, and, indeed, of *B. ovalis*, as is shown by a perfect specimen from the Lias of Lyme Regis, in Miss E. Philpotts' collection. "The Belemnites have, therefore, the plate of *Onychoteuthis*, as a prolongation of the alveolus, and, internally, the ink-sac of *Sepia*."

We shall find reason to believe, however, that what Von Zieten figures in the plate referred to are pens of *Loligida*. And it must be particularly observed that Agassiz and Buckland, though apparently in agreement, are not really so. Dr. Buckland neither assents to the proposition that the pens figured by Von Zieten belong to Belemnites, nor does he agree with Professor Agassiz' opinion that Miss Philpotts' specimens exhibit traces of such a pen.

In the paper entitled "Bemerkungen über das genus Belemnosepia und über den fossilen Dinten-sack in den vorderen Kegel der Belemniten," in fact, Buckland speaks of Von Zieten's specimens as "species of *Loligo*" (p. 39, note), and in the Bridgewater Treatise, p. 308, when treating of the pens and ink-bags of "*Loligo*" in the English Lias, he says,—

"We learn from a recent German publication (Zieten's *Versteinerungen Wurtembergs*, Stuttgart, 1832, Pl. 25 and Pl. 37), that similar remains of pens and ink-bags are of frequent occurrence in the Lias shales of Aalen and Boll."

Taking for granted the correctness of Professor Agassiz' interpretation of the pen called "*Onychoteuthis prisca*," as the pro-ostracum of *Belemnites ovalis*, M. Voltz contributed much towards the acceptance of that interpretation by essaying to prove (Ueber *Onychoteuthis prisca* von Münster; Leonhard und Bronns *Jahrbuch*, 1836, p. 323), that the arrangement of the lines of growth in the former corresponds with that of certain striations upon the conotheca of Belemnites to which he had drawn particular attention in his "Observationes sur les Belemnites" (1830). These are two systems of very remarkable striæ visible on the outer surface of the lamellated test composing the conotheca: "the one kind are straight and set out from the apex, they are analogous to the longitudinal striæ of all univalve and bivalve shells; and the others are more or less transverse." The first set are usually well seen only in the ventral or internal face. "Commonly, the external lamina of the conotheca shows them more distinctly than the internal laminae, whilst the other striæ are seen equally

“ well on all the laminae. These last indicate the mode of its progressive growth, and, consequently, the form which the opening had during the whole period of its growth.

“ These striae of growth form a series of transverse semicircles, parallel with the sutures of the septa, on the ventral face of the phragmocone. There are always many on each alveolar chamber, and they are the closer together the nearer they are to the apex. This arrangement is seen only on the ventral face of the phragmocone; and when the striae reach the lateral regions they assume an almost hyperbolic curvature to approach the straight lines which pass from the apex of the cone and run, between the side and the back, as far as the aperture. I shall call these lines the *asymptotes*, and the lateral regions where the striae have a hyperbolic curvature, *hyperbolic areae* (régions hyperboliques); the region between the *asymptotes* I shall term the *dorsal area* (région dorsale). The transverse striae sometimes unite in groups into a single line, when they take the hyperbolic curvature and ascend towards the asymptote. The width of the dorsal area, that of the hyperbolic areae, the quantity and the curvature of the striae of these different areae, vary according to the species; but this variation is very slight. The width of the dorsal area is usually about one-fourth of the circumference, and that of each of the hyperbolic areae an eighth.

“ The striae of the dorsal area are less numerous than those of the rest of the test, and are usually less pronounced than the latter, being sometimes imperceptible; they form ogive arcs, the apex of which is turned towards the aperture of the shell. Often, one sees a slightly raised straight line, which sets out from the apex of the cone and intersects the summits of all the ogives; at other times a groove traverses the region; and occasionally the ogives are not visible.

“ It would appear from these facts that the ventral edge of the aperture of the phragmocone is parallel to the sutures of the septa, and that, on the sides, it curves round almost at a right angle to form an elongated lobe, which terminates in an ogive arch on the dorsal side.”

The existence of these *conothecal striae* has been noted by all observers, and Voltz's clear description of their distribution and direction has been largely confirmed. I shall have to point out, however, that one species of Belemnite, at any rate, exhibits a different pattern.

The view taken by Agassiz and Voltz of the nature of the Liassic pens, formerly referred to *Loligo* and *Onychoteuthis*, met with strong opposition in an essay by Prof. Quenstedt, entitled “*Loligo Bollensis ist kein Belemniten Organ*,” and published in Leonhard and Bronn's Jahrbuch for 1839.

Prof. Quenstedt points out, with great justice, firstly, that the markings on the pens are quite different in character from those on the phragmocones of any known Belemnites; and, secondly, that the posterior ends of the pens are complete, and certainly were not united with any such structure as a Belemnite, while it is impossible to imagine that the latter should have been attached to the anterior ends of the pens.

In 1840, however, M. Voltz, in his “*Observations sur les Belopeltis ou lames dorsales des Bélemnites*,”\* brings forward new arguments in favour of Agassiz' opinion.

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\* *Memoires de la Société d'Histoire Naturelle de Strasbourg*.—June 1840.

In the first place he gives a clear view of the structure of *Belemnites* in general, repeating and extending his previous statements, and more especially defining his opinion as to the meaning of the conothecal striæ.

“As the striæ of growth represent the successive openings of shells, one is always enabled to form an exact idea of the form of a shell at any stage of its growth, when the whole length of these striæ is followed out, so that an exact idea of the form of the opening of the conotheca (test alveolaire) of a *Belemnite* may be formed by following one of the lines of growth.”

Voltz gives a restoration of the *Belemnite* shell constructed upon this principle in the third figure of the third plate of the work cited.

The Liassic and Oolitic pens are, for M. Voltz, the pro-ostraca of *Belemnites*; but as these *Belemnites* are unknown, he proposes for them the new generic name of *Belopeltis*. In anticipation of obvious objections, M. Voltz writes:—

“It might be supposed that the *Belopeltes* belong to some other genus of Cephalopods than *Belemnites*, or than any other known form of Acetabulifera; and the shell of which, though without a guard, had much analogy with the alveolar test [conotheca] of the *Belemnite*. But then one would ask why these *Belopeltes* are always incomplete at their apices, a fact which is fully explained, and, so to speak, becomes a necessity, when these fossils are referred to *Belemnites*. It would also be necessary to explain why no fossils are ever found which can be referred to the apex of *Belopeltis*, and why, lastly, fossils are never met with appertaining to the dorsal lobe of the alveolar test of *Belemnites*; a very much elongated lobe, the existence of which in entire and uninjured *Belemnites* cannot be doubted by any one who has carefully examined the striæ of growth of the alveolar test [conotheca] of the *Belemnites*.” L.c., p. 21.

And further, in his “Observations Supplémentaires” (l.c. p. 31):—

“M. Buckland gives, on his Plates 44' and 44'', figures representing fragments of *Belemnites* found at Lyme Regis and still containing the ink-bag. The figure 7, Plate 44', represents *Belemnites ovalis* with its ink-bag.

“It is to be regretted that M. Buckland has not published a figure of the counterpart of this specimen; for M. Agassiz, who studied this very important fossil in 1834 or 1835, and who discussed it at length with M. Buckland, says, in the German translation of the Bridgewater Treatise, that the counterpart of the fossil exhibits the dorsal region of the alveolus with striæ similar to those which are seen in Plates 28, 29, and 30 of this work,\* so that not the smallest doubt could be entertained as to the justice of the union of *Belopeltis* with *Belemnites*, a union the necessity of which was made obvious to my friend, M. Agassiz, by his first inspection of the fossil.

“M. Buckland states in his work that the specimen presents a nacreous test showing transverse and waved striæ. M. Agassiz says, on the other hand, that he does not comprehend this explanation, and that these striæ are the traces of the sutures of the septa with the alveolar cone. The mere inspection of the figure suggests the same idea, for these striæ appear to be more marked than simple striæ of growth would be, and they are placed at relative distances which correspond well to the intervals between the alveoli of *Belemnites*, and which are too great to be striæ of growth. If this be the case, it

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\* “Pen and ink-bags of *Loligo*” are represented on these plates.

evidently follows that the ink-sac is not in its natural place, since it occupies that of the septa, which would be impossible.\*

“M. Quenstedt has just published, in Leonhard and Bronn’s *Jahrbuch*, a memoir, the intention of which is to prove that the *Belopeltes* do not belong to Belemnites. He gives, in this memoir, the figure of a *Belopeltis*, which does not appear to me to be exact, because it represents the fracture which is always observed at the posterior part of these fossils, not as a fracture, but as the commencement of the shell; this would then be the point from which the successive growths which formed the shell started. M. Quenstedt had the goodness, in August 1839, to show me, in the museum of the University of Tübingen, the original of this figure, but I was unable to agree with him on this point. The striæ of growth of this fossil present no point that can be considered as the origin of the shell; the asymptotes and the hyperbolic striæ can be very well observed cutting transversely the lines which this naturalist takes for the origin of the shell; therefore the part of the shell whence its growth emanated, was inevitably situated beyond that line. The origin must have been at the point of union of the two asymptotes, and the shell is necessarily incomplete at its extremity. Now the whole theory of M. Quenstedt is based on this obviously erroneous mode of interpreting the fossil, so that it cannot be admitted.”

In 1842, M. D’Orbigny, *Paléontologie Française*, Tome 1er, p. 41, and Planches II., III., IV., described with much confidence, and figured, what he terms the “osselet corné” of the Belemnites.

“It varies but little in form, as I have been enabled to judge by the examination of more than 15 distinct species, the rostra of which are very different, while I have always found it to have the same configuration. It is composed, in front, of a broad spatuliform plate exhibiting, in the middle, a wide dorsal region† (*a*, Fig. 1, Pl. IV., et 3, Pl. III., the part comprised between the lines *b*, *b*), the angle of which always exceeds ten degrees, covered with ogive-like striæ of growth, which unite on each side at the median line, which is sometimes projecting or slightly grooved.

“On each side of the dorsal region are the lateral expansions,‡ which pass from this region and form, on each side, delicate horny plates, which are marked with lines of growth passing obliquely from above downwards, and from the dorsal to the ventral face: These expansions accompany the “osselet” through its whole length (*see* Pl. III., fig. 2, Pl. IV., fig. 1, the parts which lie between the lines *c*, *d*), and diminish in width from above downwards as far as the inferior part, where they form a longer or shorter conical cup, which appears to constitute about a third of the whole length. On the sides, at the point of junction of the lateral expansions with the terminal cup, the lines of growth suddenly become sinuated, form curves with a downward convexity, and become transverse in the whole ventral region, to give rise to the terminal cup, a kind of reversed horny cone, in which the chambers are developed successively as the animal grows.”

It appears, however, (*see* p. 43 of the work cited) that all this elaborate description of the “osselet corné” is not based upon the exami-

\* It would be interesting to know what the striæ seen upon the counterpart by Professor Agassiz really were, and why Dr. Buckland nowhere says anything about them. I suspect that they were the conothecal striæ.

† The *Asymptotes* of M. Voltz’s *Memoir*, p. 3.

‡ It is these lines, convex when the cone is reversed, which form what M. Voltz calls “hyperbolic regions.”

nation of a specimen of any such structure, but that it is deduced from the character of the markings upon the surface of the phragmocone originally described by Voltz. In point of fact D'Orbigny made no real addition to the discoveries and conclusions of the latter excellent observer.

Quenstedt (Die Cephalopoden, p. 389) agrees with Voltz in the description of the lineations of the sheath of the phragmocone, but declines to deduce thence the existence of a pen. Making no distinction between the views of Buckland and those of Agassiz, and continuing to deny the existence of evidence justifying the connexion of such pens as those of *Loligo Bollensis*, with *Belemnites*, he falls into the error of doubting Buckland's identification of the nacreous pro-ostraca, &c. of Lyme Regis with *Belemnites*; and, after a critical examination of *Belemnites semisulcatus*, he is disposed to admit, at most, "that the shell of the Belemnite alveolus (= phragmocone) did not end superiorly by a circular lip, but in a unilateral parabolic process, which can by no means be safely compared to a true *Loligo* pen."

M. Duval Jouve ("Bélemnites des Terrains Crétacés Inférieurs," 1841), observed no pro-ostracum attached to any of the specimens he studied.

In describing the specimens upon which he founded the genus *Belemnoteuthis*, in the "Proceedings of the Geological Society" for 1842, Mr. Channing Pearce indicated the existence of a "*sepiostaire*" in that genus, in addition to the phragmocone and guard.

Professor Owen, in his memoir "On the Belemnites" (Phil. Trans. 1844), having mistaken *Belemnoteuthis* for *Belemnites*, describes the rudimentary rostrum of the former as the conotheca of the latter: with regard to the existence of a pro-ostracum in *Belemnites* generally, he follows Dr. Buckland (l.c., p. 66).

In 1848 Dr. Mantell (Observations on Belemnites, &c., Philosophical Transactions) gave a more complete account of the pro-ostracum of a Belemnite (*Belemnites attenuatus*) than had previously appeared. In describing the specimen figured in his Plate XV., fig. 3, he writes,—

"This fossil comprises the following parts:—1. The capsule or *periostracum*. This external investment ( $c^1, c^1, c^1$ ), which consists of a thin, shelly, or corneo-calcareous integument that closely embraces the guard, and, gradually enlarging upwards, finally surrounds the peristome of the phragmocone, constituting the thin horny laminated sheath or receptacle ( $c, c$ ), has been described by all previous observers as an extension of what they termed the sheath, or capsule; within this receptacle the ink-bag and other viscera were probably contained

\* \* \* \* \*

The phragmocone enlarges upwards, and anteriorly to the siphonated part constitutes a large chamber, from the margin of which are produced two or more long, upright, shelly or calcareous processes, as shown in Pl. XV., Fig. 3 *b, b*<sup>1</sup>."

In a subsequent memoir\* Dr. Mantell shows that there were but two of these processes, that they were situated nearer the dorsal than the ventral aspect of the phragmocone, and that they were continued downwards into "nacreous bands or plates, finely striated" upon the outer surface of the chambered cone.

As I have already indicated, Quenstedt (Die Cephalopoden, 1849) discusses the question of the presence or absence of a pen in the *Belemnites* at great length, without arriving at any decided result;

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\* On the structure of the Belemnite and *Belemnoteuthis*.—Philosophical Transactions, 1848.



and Bronn (Lethœa, dritte Auflage, Bd. II., 1851-2) increased the confusion which had already spread over the subject, by following Quenstedt in his scepticism respecting the truly Belemnitoid character of *Belemnoteuthis*, and by referring the *Belemnosepia* of Buckland to the family of the *Loligida* and the genus *Belopeltis*. At least he does this at p. 407 of the work cited, while at p. 385 he seems to entertain a different opinion :

“ The animal of the Belemnite is perfectly unknown ; what Buckland, Agassiz, and R. Owen say of it must be referred to *Belemnoteuthis*, which only on account of accidental juxtaposition has been taken for a part of a Belemnite. Of an ink-bag also no trace is ever seen.”

That the specimens described by Professor Owen as the animals of the *Belemnite* are *Belemnoteuthes*, as Pearce, Cunningham, and Mantell demonstrated, admits of no doubt, and has since been acknowledged by Mr. Owen (“Palæontology,” p. 113), and that Agassiz was in error in identifying Von Zieten’s *Onychoteuthis prisca* with a Belemnite, also seems to be clear ; but Buckland is in a totally different position, and it will be seen that his interpretation of the Lyme Regis specimens was in the main correct.

Of the pro-ostracum (hornige Dute) Bronn says that “ it has never been found entire, and rarely in a substantive form, but its composition must be judged by combining fragments and their lines of growth.” In fact he essentially adopts Voltz’s view of its structure and extent.

Professor Quenstedt’s final opinions appear to be stated in his “Handbuch der Petrefakten-kunde” (1852). After describing the conothecal lines, he says (p. 385), “ It is but rarely that all these markings are distinctly visible, and especially they do not agree with those on the pen (schulpe) of the parabolic Loliginites, as was for some time wrongly asserted, and as some still maintain. On the other hand, they indicate the end of the conotheca (alveolarschale), as it has long been known from Solenhofen, and has been lately figured by Mantell, also from the Oxford clay at Trowbridge in Wiltshire (Philosophical Transactions, 1848). From two corresponding specimens, which I have lately obtained from Solenhofen, the fig. 13 of plate 31 is constructed of half the natural size. The conotheca (A) is chambered up to its upper part, but when the chambers cease, the lip also ends upon the ventral side, as it seems by a horizontal boundary, which would answer to the horizontal lines, *b*, upon the conotheca of *B. giganteus*. Dorsally, on the contrary, a high parabolic shield extends, at the edges of which two sometimes deeply coloured bands, *h, h*, are clearly perceived, and end in points like sharp ears superiorly. These are the hyperbolar regions, which, where they bend down below from the margin, have quite the same curvature as in *Belemnites giganteus*. Between these horns lies the region of the dorsal curves, *a, a*, with a median line *r*, in which the lines of growth are plainly curved upwards, just as the free margin of the shield is.”

Professor Quenstedt’s observations thus clearly confirm those of Mantell, and go to prove that some Belemnites have a two-ribbed pro-ostracum ; but he is, as we shall see, in error in supposing that all *Belemnites* have a pro-ostracum like that of his specimens ; and still more in his assumption (p. 333) that *Belemnoteuthis* has no phragmocone, and is not one of the *Belemnitida*, but an *Onychoteuthis*.

Professor Pictet (“Traité de Paléontologie,” 1854), follows d’Orbigny (or rather Voltz,) as to the pro-ostracum of Belemnites, and with Bronn separates *Belemnosepia* from the *Belemnitida*, while, on the other

hand, he is inclined to admit *Belemnoteuthis* as a distinct genus of the last-named family.

Mr. S. P. Woodward (Manual of the Mollusca, 1851) states that the "Pen" of the Belemnites is "represented by the nacreous bands on the dorsal side of the phragmocone, and produced beyond its rim in the form of sword-shaped processes (Pl. II., fig. 5)." From this description and the reference to the figure of *Belemnites Puzosianus* from the Oxford clay (= *B. attenuatus*, Mantell), it is clear that Mr. Woodward conceives that the pro-ostraca of Belemnites, in general, are constructed upon the type of that of *B. Puzosianus*.

Mr. Woodward identifies *Belemnosepia* with *Geoteuthis*, and therefore refers Buckland's specimens to the *Teuthidæ* and not to the *Belemnitidæ*. In his Supplement, published in 1856, the same author writes (p. 449),—

"*Belemnites*.—Professor Buckman of Cirencester possesses a phragmocone from the Lias, containing the fossil ink-bag."

Professor Owen (Palæontology, 2nd ed., 1861, pp. 111, 112), in speaking of the remains of "Calamaries (*Teuthidæ*)," states that "the most common form of the gladius has the shaft wide and longer than the wings; it has a nacreous lining, and is usually accompanied by a large and well preserved ink-bag (*Geoteuthis*, fig. 34, 4). These were called *Belemnosepia* by Agassiz and Buckland, who supposed them to belong to the same animal with the Belemnite."

But I am not aware that any one has yet observed a calamary's "gladius," with a nacreous lining; and we have seen that Buckland entertained no such opinion as that here ascribed to him.

*Belemnoteuthis* is identified with Münster's *Acanthoteuthis*. Of the Belemnites, Professor Owen, adopting Dr. Mantell's results, says, "The last chamber is rarely preserved, and appears to have thinned off into a mere horny sheath with, sometimes, two pearly bands like knife-blades on the dorsal side. It must have been sufficiently capacious to contain all the viscera. The ink-bag has been very rarely found, and is even smaller than in the last genus, as if in relation to the more greatly developed shell."

From the preceding survey of the literature of the subject it appears that very diverse opinions obtain respecting the nature and character of the pro-ostracum in *Belemnitidæ*.

1. According to Dr. Buckland this part is a corneous, or shelly, and more or less completely nacreous, extension forwards of the lip of the phragmocone.

2. According to Agassiz it is a "pen" identical with that of the so-called *Loligo Bollensis*, &c.

3. According to Voltz, it is a pen analogous to that of *Loligo Bollensis*.

4. According to Mantell and Quenstedt, it is a broad dorsal plate, more or less corneous in the middle, and with two strong calcified asymptotic bands.

Furthermore, as to the existence of specimens proving that the Belemnite was provided with an ink-bag; some, like Buckland and Woodward, affirm the fact as a matter of direct observation; others support the conclusion that the ink-bag existed in *Belemnites*, by the analogy of *Belemnoteuthis*; while yet others, denying *Belemnoteuthis*, or Buckland's Liassic specimens, to belong to the *Belemnitidæ*, doubt the existence of any direct, or conclusive indirect, evidence of the existence of this organ in the *Belemnitidæ*.

So with regard to the acetabular hooks and beaks : that such structures appertained to *Belemnoteuthis* was proved by Pearce and Cuninghton and by Professor Owen ; but, at present, I am aware of no direct evidence of their existence in *Belemnites*.

These lacunæ in our knowledge of one of the most important of extinct forms of life are filled up by the specimens described in the present Memoir, which demonstrate the accuracy of Dr. Buckland's view of the nature of the Lyme Regis fossils figured in his Plates 44' and 44''; and furthermore, prove that at least three types of structure of the pro-ostracum must be distinguished among the *Belemnitidæ*.

Some time ago, my friend Mr. Day of Charmouth was good enough to direct my attention to a number of remarkable specimens of *Belemnitidæ* obtained from the Lias in his neighbourhood, and now either in his own possession, or in that of the Rev. Mr. Montefiore and Mr. Henry Norris, gentlemen to whom I am greatly indebted for the readiness with which they have entrusted valuable and important fossils to me for examination and description.

The most complete Belemnite in existence, to my knowledge, is that specimen, the property of the Rev. Mr. Montefiore, which is represented in Plate I., fig. 1. Mr. Day informs me that it was obtained from the *Ammonites obtusus* zone of the Lower Lias near Charmouth.

In this remarkable fossil not only are the guard, phragmocone, and pro-ostracum preserved, but the general contour of the body is shown, the beak is in its place, and irregular lines of hooks indicate the position and extent of the arms.

The length of the whole animal, from the summit of the beak to the apex of the guard, is  $12\frac{1}{2}$  in., while its greatest breadth does not exceed  $1\frac{3}{4}$  inches. The arms, as indicated by the lines of hooks, cannot be traced for a distance of more than  $1\frac{1}{2}$  in. from the beak, and they diverge from one another, so as to include a triangular space, the broad base of which is superior, while its apex is close to the beaks.

The internal shell is 11·8 inches long, and consists of guard, phragmocone and pro-ostracum. The guard and the phragmocone occupy rather less than the half of the whole shell (5·5 in. about). The guard, about 0·3 in. thick in the middle, and nearly circular in section, remains of about the same diameter for  $1\frac{1}{2}$  in., widening, above, into the alveolus for the phragmocone, while, below, it tapers to the apex. The inferior narrowing commences at about half an inch from the apex, which is marked by five indistinct, short, longitudinal grooves. Superiorly, the guard spreads out over the phragmocone, becoming gradually thinner, and ceasing to be traceable, as guard, at the point (*d*), about  $2\frac{3}{4}$  in. from the apex.

The guard is broken at the points *b* and *c* ; at *b* the surfaces correspond perfectly, but at *c* there is a slight loss of substance, so that the portion of the guard, *a*, *c*, may not be in quite its natural position relatively to the rest. I am inclined to suspect that there has been some slight shifting of position at this point, from the circumstance that the curved contour of the right side of the guard is somewhat more convex than that of the left side, while the whole guard is slightly flattened in the plane of the surface of the matrix. The right contour should therefore be ventral, and the left dorsal. But there can be hardly any doubt that the upper face of the body of the specimen is the dorsal aspect, so that it would appear that the guard, where broken at *c*, has undergone a certain twist upon its axis.

The primary chamber of the phragmocone probably lies in the guard about the point indicated by the letter *x*. For the two lateral margins

of the phragmocone, if produced, would meet thereabouts; and furthermore, while at the line of fracture, *c*, the diameter of the phragmocone is nearly equal to that of the guard, the latter forming a layer not more than  $\frac{1}{25}$  in. thick round it, at *b*, the guard is solid throughout. Where the guard ceases to be traceable on the phragmocone at *d*, it is 0.75 in. broad, and the phragmocone gradually widens, until at *e*, the furthest point to which it can be traced, it is  $1\frac{1}{2}$  in. broad. It must be recollected, however, that these dimensions are exaggerated by the crushing and flattening of the specimen.

From *e* to *f*, a distance of  $2\frac{1}{4}$  in., the pro-ostracum is represented by a delicate lamella of shelly substance, for the most part exhibiting a beautiful nacreous lustre, and as wide as the upper diameter of the phragmocone. The central part of this lamella is blackish, with metallic reflections, and its edges are constricted in the middle, so that it appears saddle-shaped. At the sides it passes into a lamina of yellow nacre (*h*), which dips down towards the ventral side of the body, and is traceable, on the right side, as far as the point (*h'*). Beyond this, no remains of any shelly matter are distinctly visible, but the surface of the matrix exhibits an irregular impression, extending as far as (*i*), as of a thin, broad, partially crushed, oval extension of the pro-ostracum. I presume that the mantle of the animal also terminated at this point. Beyond it, the impression of the head is indistinctly traceable; and it is worthy of note that the head seems to have been small as compared with the size of the body. The oral circle, embraced by the bases of the short, uncinated, arms (*l*), is particularly narrow, so that these bases are closely approximated. What was the precise number of the arms, and whether any long tentacles did or did not exist, cannot be ascertained.

The remains of the beak (*k*), about half an inch long by 0.4 in. wide, are so crushed and broken that there is some difficulty in the way of interpreting the appearances it presents. I believe, however, that the two beaks are fractured transversely, the dorsum of the dorsal beak, and the edges of the ventral beak, having been left in the absent matrix; and I take *k* to be the fractured edge of the dorsal beak surrounded by *k'*, that of the ventral beak.

The substance of the beak is black and carbonized, and exhibits no evidence of any calcareous coat. The irregularly dispersed hooks do not seem to have remained in place upon the bases of more than two of the arms. There are indications that they were disposed in double rows of opposite hooks along each arm.

The most perfect of these hooks (Pl. I., fig. 1a) measures about one sixth of an inch in a straight line from its base to its apex. The basal part seems to be nearly square, and is hollow; from the base the hook is continued at first in nearly a straight line, and then bends sharply round to its acute point. The cavity of the base is traceable through the hook, and probably terminates by an aperture at, or close to, its point.

The ink-bag is not very clearly distinguishable (a dark spot at *m* only indicating its place) in this specimen; the great value of which consists in the demonstration which it affords of the co-existence of horny hooks and beak, a nacreous pro-ostracum, and the ordinary guard and phragmocone of a Belemnite; and, incidentally, of the justice of Dr. Buckland's identification of the Lyme Regis "*Belemnosepiæ*" with *Belemnites*.

So much difficulty attends the identification of the species of the *Belemnites*, that I hesitate to attach any specific name to this specimen. In many respects it is closely allied to the *Belemnites elongatus* of Sowerby; but the *Belemnites Bruguierianus* of D'Orbigny is abun-

dant in the bed in which it was found, and my colleague, Mr. Etheridge, is of opinion that it belongs to that species, "though it has strong affinities with *B. Fournelianus* (D'Orb)."

In the collections of Liassic fossils to which I have referred, and chiefly in that of Mr. Day, there is a series of fragmentary Belemnitic remains, consisting for the most part of ink-bags, associated sometimes with more or less of the pro-ostracum, sometimes with hooks and imperfect beaks in very nearly natural relative positions; sometimes with more or less of the phragmocone, but hardly ever with a guard. That these belong either to the species already described, or to a closely allied one, is highly probable; in any case, the study of the features presented by some of them may help to throw light on the structure of the *Belemnitidæ* generally.

1. In a great many Belemnites I have observed conothecal striae having the arrangement described by Voltz (Plate I., figs. 6 and 7); but a large phragmocone from the *Ammonites obtusus* zone in the Rev. Mr. Montefiore's collection, the apex of which is broken off, but which still has a width of  $2\frac{1}{2}$  in. and a length of five inches, exhibits a disposition of the conothecal lines different from any which I have met with, or seen described. (Plate I., fig. 4a.)

Only a small portion of the conotheca is preserved in this specimen, coating the cast of a phragmocone in calcareous spar, which exhibits the remains of the siphuncle very distinctly along the middle line of that face of the specimen which is turned to the right in the figure. This is, therefore, the ventral line, and the face turned to the eye is the left lateral face of the phragmocone, the figures not having been reversed. Now it will be observed that instead of one *asymptote* as usual, there are two, separated by an interval equal to about  $\frac{1}{4}$ th of the circumference of the phragmocone. Sharply arched hyperbolic lines, the ends of which pass into the asymptotes, and which are convex upwards, occupy the space between the two asymptotes; of which the one may be termed the *dorso-lateral*, the other the *ventro-lateral* asymptote.

Faint curved lines run obliquely upwards from the dorso-lateral asymptote towards the middle line of the dorsal region, so that the dorsal area of the conotheca doubtless had its usual set of upwardly convex curved lines. The ventral area, on the other hand, enclosed between the ventro-lateral asymptotes, exhibits no very distinct markings, though faint indications of transverse lines are discernible.

The conotheca in this case, therefore, differs from the ordinary type in having three sets, one medio-dorsal and two lateral, of upwardly convex curved striae, and in possessing four asymptotes instead of two.

According to D'Orbigny ("Paléontologie Française," Terrains Jurassiques, Atlas, Pl. 16, fig. 1), the conothecal lines of *Belemnites Puzosianus* have the ordinary arrangement, and the lateral bands of the pro-ostracum of this species would seem to correspond with the asymptotes.

If the arrangement of the conothecal lines, then, indicates the form of the pro-ostracum and *vice versa*, the majority of Belemnites ought to have a two-banded pro-ostracum like that of *B. Puzosianus*; and, on the other hand, the peculiar arrangement of the conothecal lines of the present phragmocone ought to indicate that it was associated with a different kind of pro-ostracum; and, so far, there may be ground for

suspecting that it belonged to some of the species which have pro-ostraca like that of *Belemnites Bruguierianus*.

But I am by no means satisfied of the justice of Voltz's assumption, which D'Orbigny and others adopt, that the conothecal lines must indicate the form of the pro-ostracum, since the latter may readily have been modified by the deposition of shelly matter upon its exterior, after its first formation.

2. The guard of the typical specimen of *Belemnites elongatus*, now in the British Museum, is covered by a superficial, smooth, thin, whitish, cuticular pellicle; and a better developed cuticle of the same kind has been brought under my notice by Mr. Day in specimens from the Upper Lias. A small example of the guard of apparently the same species (Pl. I., figs. 3, 3a, 3b), pointed out to me by Mr. Day, exhibits a much more developed cuticle. This is thrown into fine longitudinal wrinkles in its upper part, but, inferiorly, the wrinkles pass into minute ridges and tubercles. Both these and the wrinkles are larger, and extend farther up, on the dorsal than on the ventral, aspect of the guard.

Is the existence of this cuticular pellicle an indication of the completion of the growth of the Belemnite?

3. A splendid specimen in the collection of Mr. Norris (Plate II., figs. 1 and 1a) shows very clearly the association of a phragmocone with a nacreous pro-ostracum and a large ink-bag. On the one face (fig. 1) this fossil exhibits the dorsal part of the pro-ostracum and its continuation into the guard, while, on the other face (fig. 1a) the huge ink-bag is displayed. The saddle-shaped, highly iridescent, region of the dorsal part of the pro-ostracum (*a*) terminates in well defined margins, both laterally and in front, the portion of the pro-ostracum with which it was continuous, at the sides, having broken away from this central region. On the left side, however, the lamellar continuation of the pro-ostracum towards the ventral surface (*b*) is well shown; and, like the dorsal portion, it is highly iridescent. When subjected to an oblique light, the pro-ostracum exhibits a shallow medio-dorsal longitudinal groove and indistinct lines of growth, which are convex upwards. The surface which continues the direction of the iridescent part of the pro-ostracum upwards (*c*) has a granular pitted surface; but I am doubtful whether this appearance is due to the structure of the pen in this region, or to the manner in which fossilization has taken place.

The ink-bag is flask-like, 8 inches long, and  $1\frac{3}{4}$  inches wide at widest.

4. In Mr. Day's collection, there is a specimen (No. 9) from the *Ammonites obtusus* zone, consisting of the upper part of the phragmocone, with almost the whole of the pro-ostracum, and the remains of many hooks in place.

A length of about  $2\frac{3}{4}$  inches of the phragmocone is preserved; its upper end is  $2\frac{1}{2}$  inches wide, its lower end somewhat more than 1 inch, but both ends are greatly crushed. Nacreous shelly substance coats the exterior of the upper part of the phragmocone, and extends upwards over more than the lower half of the pro-ostracum, which has an oval form, and is nearly 10 inches long by  $3\frac{1}{2}$  inches wide.

The upper four or five inches of the middle portion of the pro-ostracum is formed of a thin plate of shelly matter, which is not iridescent, and beneath which there is no iridescent nacre. In the lower part of the pen the external non-iridescent substance has a subjacent, beautifully iridescent layer. In this, as in other cases, the nacre is bounded by a well-defined upper contour, which in this instance is convex.

The hooks of one arm have remained in position, and are arranged in two rows, and opposite to one another. One hook is so imbedded in the matrix as to expose its outer or convex side. In this, as in the lateral position, the base is much wider than the shaft of the hook.

The guard is not preserved in any of the preceding fragmentary specimens, while the ink-bag is but indistinctly traceable in the entire one first described. But any hypercritical doubt that might remain as to the possession of an ink-bag by a true Belemnite, must be removed by Mr. Day's specimen of *Belemnites elongatus* represented of one-half the natural size in Plate I., fig. 2, which exhibits the guard and phragmocone complete, with a large and full ink-bag *in situ*. The ink-bag is pear-shaped, and tapers off to its duct. The length from the extremity of this to the base of the bag is 1·4 inch, the widest part of the bag measuring 0·55 of an inch. The shell from the apex to the mouth of the phragmocone is 5·35 inches long. The guard from its apex to the point at which it begins to expand over the phragmocone measures about  $2\frac{1}{4}$  inches, and is 0·25 of an inch wide at widest.

These measurements may enable one to form a rough estimate of the size of guard which appertained to any detached ink-bag, and *vice versâ*.

I have not been able to make out more than six or seven arms in any specimen, nor has any exhibited traces of elongated tentacula, though the shortness of the arms which have been preserved would lead one to suspect their existence. The hooks in the middle of the length of each arm seem to have been largest; those at the ends of the series, especially at the base, smallest.

The foregoing descriptions demonstrate that certain true Belemnites were provided with hooks upon their arms; horny beaks; large ink-bags; and with a pro-ostracum (into which iridescent, nacreous, shelly matter entered more or less largely) prolonged as a broad spatulate plate along the whole length of the dorsal region of the mantle, and produced laterally and inferiorly, for an unknown distance, along the lateral and ventral regions of the body.

But it by no means follows that all *Belemnitidæ* were provided with a pro-ostracum of similar form and character. On the contrary, it appears to me to be certain that there were at least two other kinds of pro-ostracum in this family.

Thus the Oxford Clay Belemnite, described by Mantell (Phil. Trans., 1848), under the name of *attenuatus*, a name which appears, like *B. Owenii*, to be only a synonym of *B. Puzosianus* (D'Orbigny) has a pro-ostracum which was very thin and apparently horny, or imperfectly calcified, in the dorsal region, and was supported laterally by two thin calcareous bands, or pillars, which, inferiorly, expand upon the conotheca.

A third very distinct type of pro-ostracum is exhibited by that remarkable Belemnitoid originally figured and described under the name of *Orthocera elongata*, by Sir Henry De la Beche,\* who says in a note (l. c., p. 28), "I have ventured to class this specimen as an *Orthocera*, as "it possesses more of the character of that genus than of the Belemnite,

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\* On the Lias of the coast in the vicinity of Lyme Regis, Dorset.—Transactions of the Geological Society, ser. 2nd, vol. ii. (1829), Pl. IV., fig. 4.



“ the external shell not exhibiting the radiating fracture of the latter,  
 “ and I have given it a specific name from its great length in proportion  
 “ to the diameter. Mr. White, to whom I am indebted for the specimen,  
 “ informs me that it was originally considerably longer than at present.”

As this specimen (now in the Museum of the Geological Society) is by no means well represented in the plate accompanying De la Beche's memoir, I have had a correct sketch of it made (Plate III., fig. 3).

It consists of an imperfect sub-cylindrical guard 3·2 inches long; fractured above and below, and having, in its lower part, a diameter of rather less than one-fifth of an inch. It contains the remains of a long tapering phragmacone, the chambers of which have been completely filled with transparent calcareous spar. The rounded, bead-like apical chamber of the phragmacone, not one-fortieth of an inch in diameter, is situated at about 0·2 of an inch from the fractured extremity of the guard. The chambers gradually increase in length and in breadth, until at 2·25 inches from the apex they are 0·2 of an inch long by 0·25 wide. Beyond this point, the phragmocone is broken away, but the impressions of three chambers are left on the inner surface of the conotheca, which adheres to what remains of the attenuated, upward, prolongation of the guard. Altogether, there seem to have been about 30 chambers in the 2·9 inches length of phragmocone, but the 10 outermost chambers take up 1·8 inches of this extent. The conotheca is a thin lamella of a much paler colour than the guard, to the walls of the alveolus of which it adheres.

The real nature of this “ *Orthoceras* ” was first revealed by the beautiful specimen obtained by Mr. Day, which is represented in Plate III., fig. 1, reduced to four-fifths of the natural size. Here, the apex of a phragmocone of similar character is inclosed within a subcylindrical guard, obtusely truncated at its free end. For an inch and a half from its distal end, this guard is entire, but beyond this point (*b*) it is split, and the dorsal has come away from the ventral half, leaving the phragmocone (*c*) exposed. The chambers of the phragmocone are filled with transparent spar, and their casts, thus produced, are exposed to view inferiorly. Superiorly, they are coated over by a thin pellicle of quite a similar character to the theca of the phragmocone in the original specimen; and, indeed, at the sides, this layer dips down between the fractured edge of the guard and the phragmocone, showing clearly that it is the conotheca.

At 3·6 in. from the end, the specimen is transversely fractured, and the section of the guard cannot be traced further than the fracture; but a layer of shelly matter (*a*) quite similar to that which forms the conotheca, and which was obviously continuous with it, coats what appears to be the upper termination of the phragmocone, and passes into the remarkable pro-ostracum, the extreme point of which is broken off: when it was entire it measured about  $11\frac{3}{4}$  inches. Posteriorly it is a flat band 0·35 in. wide, which slowly narrows until its width is about 0·2 in.; it then widens to 0·5 in., and, finally, gradually tapers to its point. Where it widens it thickens, and its surface, from being flat, becomes convex from side to side, so that its section acquires the form of a not very depressed ellipse, and this form is retained close to the apex at *f*.

The surface of this singular pro-ostracum is polished, but is covered with transverse wrinkles, or ridges, which are especially numerous where the flat portion passes into the rounded part.

The sections of the pro-ostracum exhibit its structure. Like the guard of an ordinary Belemnite, it is composed of concentric lamellæ, each of which consists of fibres disposed perpendicularly to the plane of the



lamella, whence the cut surface presents concentric and radiating structure lines.

What the proper structure of the guard may be is more doubtful. In all specimens I have examined the texture of the guard is dense and thoroughly calcified, and any indications of structure are of a crystalline and not an organic character. The guard of the specimen longitudinally and vertically bisected, of which a diagram, twice the natural size, is given in Plate III., fig. 3, presents a dark longitudinal axial line, a dark terminal transverse line, and another less dark transverse line rather above the middle of its length.

The terminal transverse dark line is visible on the exterior of the specimen, and looks at first like a colour band, a sort of indication of the natural termination of the guard. But, on closer examination, these transverse markings are seen to arise merely from the presence of plates of calcareous spar; in other words, the calcareous infiltration is transparent in these parts of the fossil. The dark axial line appears to me to result from similar conditions.

The internal shell just described has not yet been found associated with ink-bag, hooks, or beaks. The peculiar form of the pro-ostracum, the long narrow phragmocone, and the cylindroidal guard, distinguish it generically from all the other *Belemnitidæ*. I, therefore, propose for this new generic type the name of *Xiphoteuthis*, and retain for the present, the only known species of the genus, De la Beche's term of *elongata*.

Is the guard entire in these specimens of *Xiphoteuthis elongata*, or has its apex been broken off? Was it originally solid and composed of fibrous lamellæ, or was it, like *Belemnites tubularis*, hollow through a greater or less part of its extent? The specimens which have passed through my hands do not enable me to give a definite reply to these questions.

I suspect that a thoroughly well-preserved specimen of *Belemnoteuthis* will some day demonstrate the existence of a fourth kind of pro-ostracum among the *Belemnitidæ*. Mr. Pearce, as we have already seen, speaks of a "sepiostaire" in this genus; and Mr. Woodward ascribes to it "a horny dorsal pen, with obscure lateral bands." A specimen of *Belemnoteuthis* from the Oxford Clay, in the British Museum (Plate II., fig. 2), shows very distinct traces of a pro-ostracum of this kind. The fossil is unfortunately much crushed, but from one lip of the phragmocone there obviously proceeds the horny-looking plate (*a, a*), the two lateral contours of which, obscurely defined from the matrix, pass into one another at an acute angle at *b*. A narrow band of horny-looking matter, marked by oblique striæ, is discernible at *c*, and is quite distinct from the remains of the mantle (*f*), under which it seems to pass.

Is the triangular plate part of the ventral pro-ostracum, and the band *c* the remains of the dorsal portion of that structure? I am inclined to think so, though the state of the fossil is not such as to encourage positive assertion.

It has been seen that at least two genera of *Belemnitidæ*, viz., *Belemnites* and *Belemnoteuthis*, have hooks, arranged in double rows, upon their arms. Now similar hooks, sometimes isolated, some-

times associated with more or less complete remains of the animal to which they belonged, have been discovered in abundance in the Solenhofen slates, and have been referred by Wagner and Münster to the genus *Acanthoteuthis*. The interesting question therefore arises, was there, in the Mesozoic epoch, a cephalopod (*Acanthoteuthis*) with hooked arms, distinct from *Belemnoteuthis* and *Belemnites*; or are the Solenhofen fossils in question to be referred to one or other of these genera?

Count Münster's two memoirs on *Acanthoteuthis* are to be found in his "Beiträge zur Petrefacten Kunde" (Erstes und Siebentes Heft. Zweite Auflage).

In the first memoir, the genus is founded upon specimens of four species, consisting either of hooks alone, or of remains of the body and arms, the latter retaining their hooks.

In specimens of *Acanthoteuthis speciosa*, the first species, the mantle is said to be preserved, and in it "the broad sword-like pen, devoid of any distinct ridges, is visible" (l. c., p. 105); and, in both of these, "hooks are to be seen near the upper or cephalic end, perfectly similar to those figured in Plate IX." The hooks, situated in double rows along the arms, are marked by two ridges, one of which runs near the convex, and the other near the concave, side.

The second species is *Acanthoteuthis Ferussacii* (*A. prisca* of D'Orbigny), the only specimen of which exhibits an elongated mantle with a largish head, and short arms, provided with a double row of hooks. Each hook has only one ridge, situated towards the concave side.

The third species, *A. Lichtensteinii*, has short round hooks without ridges, and the fourth, unnamed, has hooks with two fine grooves on each side. But Count Münster communicated an important observation, bearing upon the present question, in a letter to Professor Bronn, published in Leonhard and Bronn's Jahrbuch for 1836 (p. 583):--

"From Solenhofen I have the large Phragmacone (Alveolkegel) of a Belemnite, with the unchambered hollow continuation of the shell, beside which lies the injured body (Sack) of a very large *Onychoteuthis*; round about are seen a few minute hooks from the arms of the Cephalopod. The two fossils lie so close together, and partly in superposition, that one might, at first, be led to believe them to belong to one and the same animal; but more careful examination shows that they proceed from two different animals, *Belemnites semisulcatus* and *Onychoteuthis speciosa* (the largest fossil kind with which I am acquainted). Notwithstanding all the trouble which I have taken to find a *Belemnosepia* of Buckland in the slates of the Lias and of Solenhofen, I have as yet met with no success; in no German collection with which I am acquainted is there any true *Belemnosepia*, for which, at first, I took the fossil just described."

Professor A. Wagner ("Die fossilen Ueberreste von nackten Dintenfischen," 1860), however, having had the opportunity of carefully examining all Münster's specimens, and of collating them with others, leads us to believe that the earlier opinion was more correct than the later. He says (p. 820), that he was at first of the same opinion as Count Münster, but that he is now perfectly persuaded, "that on the slab in question there are not two examples of different genera, but only a single individual specimen. The phragmocone is, in fact, directly connected with the posterior margin of the mantle, and exhibits the same structure as that of *Acanthoteuthis* (*Belemnoteu-*

“ *this*) *antiqua*, although only a coarse impression of it is left. The whole length of this individual, from the base of the arms to the apex of the phragmocone, is above 14 inches.”

At a previous page (777) Wagner states that a few hooks lie beside the head of this specimen, and that the form of its body is exactly like that of *A. Ferussacii*. “But what gives this specimen its greatest value is the circumstance that, in the posterior part of the mantle-sac, at its posterior as well as at its two lateral edges, a few delicate fragments of a brown, horny, irregularly fissured pen (*Schulpe*) are visible.”

In the second essay (“Ueber die Schalenlosen Cephalopoden des oberen Juragebirgs”), Münster says he is not certain what kind of mantle or pen might have belonged to *Acanthoteuthis speciosa*, nor has he any knowledge of the pen of *A. Ferussacii*, or of *A. Lichtensteinii*; but he proceeds to describe some new species, prefacing his account of them with some general remarks, as follows:—

“The bodies of all the species known to me have a narrow elongated form, which sometimes is elliptical, sometimes ovate, sometimes fusiform, or even conical. Since, in a few specimens, impressions of hooklets are discoverable at the upper part of the body, which agree perfectly with the three foregoing, and besides, coprolites not uncommonly occur in the slates, which consist exclusively of the remains and undigested parts of these naked cephalopods, namely, of the middle keel of the pen, which is crushed into many short pieces, and of the hooklets of the arms, which, sometimes large and sometimes small, lie scattered round the fragments of the pen in great numbers; I have not hesitated to ascribe all these bodies and pens to the genus *Acanthoteuthis*, until this view is upset by complete specimens,” p. 57.

Thus ‘*Acanthoteuthis*’ *speciosa* turns out to be one of the *Belemnitidæ*, but the statements before us leave it doubtful whether it was like *Belemnoteuthis*, devoid of an elongated guard, or whether it is really a *Belemnites semisulcatus* with the guard broken off.

With respect to “*Acanthoteuthis*” *Ferussacii*, of which only one specimen exists, Wagner is uncertain as to its distinction from the former species, and believes it to be identical with *A. Lichtensteinii*; and at any rate, as the head and trunk have left only an impression, and not a trace of any internal parts is to be seen (Wagner, l.c., p. 775), there is no evidence to show that it, also, may not be a *Belemnites*, or a *Belemnoteuthis*.

Of the other *Acanthoteuthes* enumerated in the second memoir, Count Münster does not profess to have found hooks associated with *A. angusta*, *A. lata*, *A. subovata*, *A. subconica*, *A. acuta*, *A. brevis*, *A. intermedia*, *A. rhomboidalis*, *A. semistriata*, and *A. tricarinata*, all of which are referred to a different genus, *Plesioteuthis*, by Wagner; while Wagner, after examination of the same specimens, denies the existence of hooks in *A. Orbignyana* and others, to which Münster ascribed them.

Thus, the existence of *Acanthoteuthis* as a genus apart from *Belemnites*, or *Belemnoteuthis*, becomes exceedingly doubtful. But it does not follow from this that no other Mesozoic *Cephalopoda* were provided with hooked arms, and indeed there is evidence that at least two genera, *Plesioteuthis* (Wagner) and *Celæno* (Münster) were. In the first place Count Münster affirms, and Professor Wagner agrees with him, that coprolites are not unfrequently found in the Solenhofen slates, “which consist exclusively of the remains of undigested parts of naked cephalopods, namely, of the middle keel of the pen, which is crushed into

“ many short pieces, and of the hooklets of the arms, which, sometimes large and sometimes small, lie scattered round the fragments of the pen, in great numbers.” Wagner adds to this (l.c., p. 785) that the fragments of the pen are part of the keel and of the lateral wings of pens, appertaining, almost wholly, to animals in which the latter are sword-shaped and thin, and for which Wagner proposes the generic name *Plesioteuthis*. It would therefore appear that *Plesioteuthis* had hooks, though Wagner’s statement that he had never, either in Münster’s collection, or any other, found hooks associated with these sword-shaped pens,\* is, so far as negative evidence goes, somewhat against that conclusion.

In the next place, Professor Wagner (l.c., p. 783) describes an impression of *Celæno conica* displaying hooks similar to those of “*Acanthoteuthis Ferussacii*,” and, in addition, the remains of acetabula.†

Upon the whole it becomes plain that the *Acanthoteuthes* of Münster, so far as they are known only by hooks and impressions of soft parts, may have been either *Belemnites*, or *Belemnoteuthes*, or *Plesioteuthes*, or may have belonged to the genus *Celæno*; and that, with the evidence before us, it is impossible to say whether *Acanthoteuthis speciosa* and *Ferussacii* belong to *Belemnites*, or to *Belemnoteuthis*.

Under these circumstances, it appears to me that there is no good ground for abandoning the name *Belemnoteuthis*, applied by Pearce to one of the best known and most clearly definable of fossil *Cephalopoda*, for *Acanthoteuthis*. Though it is quite possible that either *A. speciosa* or *A. Ferussacii* may be really a *Belemnoteuthis*, we have no certain knowledge of the fact; and even if such be the case, it would be better to separate these forms as *Belemnoteuthis*, and to retain *Acanthoteuthis* for the *Plesioteuthis* of Wagner.

The genera hitherto enumerated in the family of the *Belemnitidæ*, characterized among the Dibranchiate *Cephalopoda* by possessing a straight, chambered, siphunculated, internal shell, or phragmocone, are *Belemnites*, *Belemnitella*,‡ *Belemnoteuthis*, *Beloptera*, and *Conoteuthis*. To these *Xiphoteuthis* must now be added, and I think it very probable that by-and-by it will be found necessary to subdivide *Belemnites*, the difference between the pro-ostraca of *B. Bruguierianus* and *B. Puzosianus* being, probably, of generic importance.

The extent of our knowledge of the structure of these different genera is very unequal. Of *Belemnoteuthis*, the body and arms, hooks, ink-bag, and internal shell are all known, few fossilized animals having left more complete remains; of *Belemnites*, the specimens described in this paper have made known, for the first time, the form and proportions of the body and the arms, the hooks, the ink-bag, one type of pro-

\* Out of coprolites, that is to say.

† Wagner speaks of these as “hitherto never observed in fossil *Cephalopoda*” (p. 783), but he has overlooked a paper “On the fossil *Cephalopoda* constituting the genus *Belemnoteuthis*,” by Mr. J. C. Pearce, F.G.S., published in the “London Geological Journal,” No. II., February 1847, in which the acetabula of *Belemnoteuthis* are described and figured. (Pl. XVI.)

‡ See, however, with respect to *Belemnitella* and *Actinocamax*, the important observations of Saemann, “Observations sur *Belemnites quadratus*, Deifr.”—Bull. de la Société Géologique de France, 1862. M. Saemann brings forward evidence to show that these apparently distinct generic types arise merely from the defective calcification of the upper part of the rostrum of a *Belemnite*.

ostracum ; and, less perfectly, the beak ; of *Xiphoteuthis*, the almost complete internal shell is known ; of *Conoteuthis*, the phragmocone and part of the pro-ostracum ; of *Beloptera* and *Belemnitella*, only the phragmocone and guard ; but with the hooks, ink-bag, or soft parts of these last four genera we have no acquaintance.

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