VI. *A Description of certain Belemnites, preserved, with a great proportion of their soft parts, in the Oxford Clay, at Christian-Malford, Wilts.* By Richard Owen, *Esq., F.R.S., &c.*

Received March 14,—Read March 21, 1844.

THE extinct Cephalopod, called *Belemnite*, has long been known by its peculiarly complex shell, which includes a part possessing the chambered and siphonated structure characteristic of the entire shell of the *Spirula* and *Nautilus*, and the fossil *Orthoceratites*, *Baculites*, *Ammonites*, &c. Like the latter unequivocal congeners of the still existing Nautilus, the Belemnites are distributed through a vast series of the secondary rocks from the epoch of the muschelkalk, when they seem first to have been introduced into the old ocean of this planet, up to the Maestricht chalk, when they finally perished.

No fossil shell has more exercised the ingenuity and research of the interpreters of ancient Nature, or has given rise to so many conflicting opinions as to the affinities of its animal constructor, than the Belemnite: but the specimens from the Oxford clay near Christian-Malford, in Wiltshire, liberally presented by the Marquis of Northampton, P.R.S., Samuel Peace Pratt, Esq., F.R.S., and William John Broderip, Esq., F.R.S., to the Royal College of Surgeons, leave no reasonable ground for further hesitation or scepticism on the subject, since they display in a truly marvellous manner, those soft and seemingly most perishable parts of the animal which are essential to convey a true idea of its living form.

It must, however, be premised in vindication of the fruitful principle of physiological correlations, established by Cuvier as the key to the interpretation of fossil remains, that, for some years prior to this discovery, there had been obtained sufficient evidence of the organization of the Belemnite, to determine both its ordinal and family affinities; but, as the value of this evidence failed to be appreciated by some experienced palæontologists, from want of sufficient knowledge of, or faith in, the laws of the interdependencies of the characteristic parts of the Cephalopodal organization, the additional facts afforded by the well-preserved specimens from the Oxford clay are most acceptable and valuable.

In the compound shell of these specimens the following parts are recognizable:—

1st. The terminal spathose body called the '*guard*,' sheath or rostrum*, resembling the head of a dart or javelin, whence the name Belemnite originally given to this part

* Plate II. fig. 1, *a*.

of the shell, which is usually the only part preserved, and now extended in its application to the entire animal.

2nd. The chambered or siphonated part of the shell which I have called the '*phragmocone**,' and which is lodged in the conical alveolus or cavity at the base of the 'guard.'

3rd. The conical, thin, but dense, corneo-nacreous case†, which immediately invests the phragmocone, and lines the alveolus of the guard; commencing at the bottom or apex of that cavity, and continued beyond the thin margins of the basal aperture of the alveolus, and beyond the last septum of the phragmocone, to form, as Dr. BUCKLAND rightly describes‡, the large anterior chamber of the Belemnite containing the ink-bag and some other viscera.

The numerous species of Belemnite have been classified according to the modifications of the spathose guard; the one under consideration belongs to the group characterized by a rounded, elongated, conical guard, with a short, terminal, ventral, longitudinal impression; it was first recognised as a new species by Mr. PRATT, who has honoured me by naming it *Belemnites Owenii*. This species approximates in its general form to the *Belemnites elongatus* and *Bel. longissimus* of MILLER, from the lias; but it presents intermediate proportions of length to breadth, and maintains the same diameter throughout a much greater part of its extent; the anterior expansion, which is very gradual, commencing, nevertheless, nearer the alveolar extremity, and ending less widely. The excavated part of the guard becomes very thin as it expands, and, there having been no infiltration of mineral matter into its cavity, or into the chambers of the phragmocone, it has yielded to the pressure of the superincumbent strata, and thus in its flattened and fractured state shows a greater degree of expansion than is natural to it. The thin and brittle margin of the spathose alveolus may be traced nearly half way towards the base of the phragmocone, which is there invested only by the thinner and more yielding corneo-nacreous sheath§.

The gradual expansion of the guard from its posterior end or apex is shown in the figure 1. The ventral groove (fig. 2 *a'*) extends to about one-fourth the length of the guard, commencing a little in advance of the apex: it is very shallow, with the

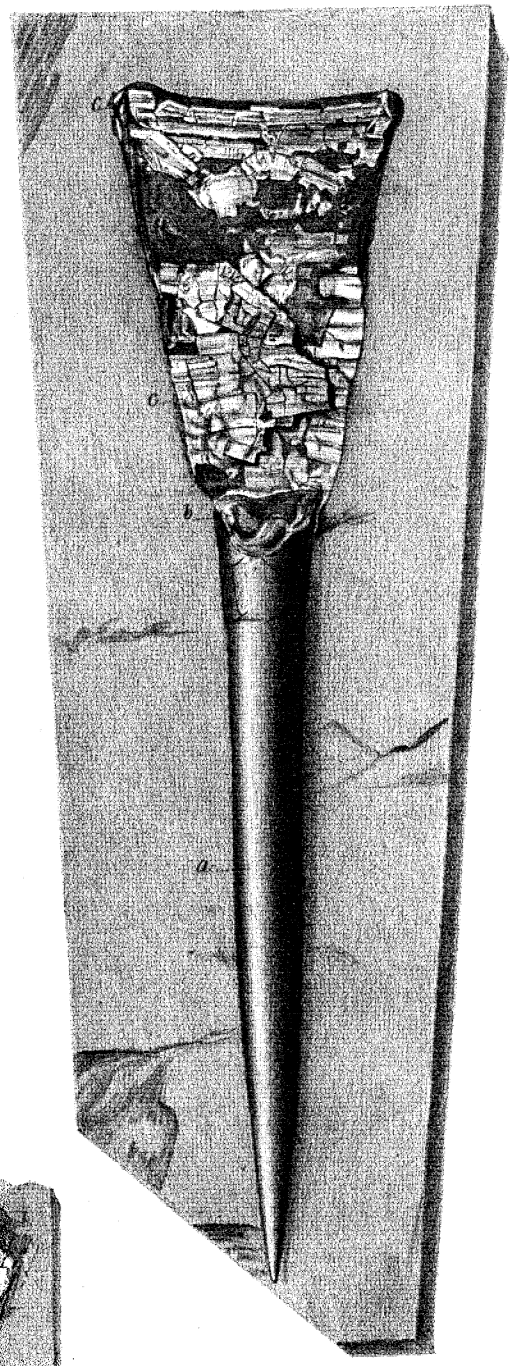
* Pl. II. figs. 1 *c*, 6, 7 and 8. Φραγμὸς partition, κῶνος cone. Lectures on Comparative Anatomy, 8vo, 1843, p. 333. The term 'alveolus' has usually been applied to the chambered cone; but it appears better to restrict it to the socket in which the chambered cone is lodged.

† Pl. II. fig. 6, and fig. 7, *η*.

‡ Bridgewater Treatise, 1836, p. 372.

§ In the specimen of *Belemnites elongatus* figured by MILLER (Geol. Trans. 1826, Pl. VII. fig. 6.), this thin sheath, which extends beyond the wider part of the alveolus, had perished, as is usually the case, and the casts of the chambers of the phragmocone, which is preserved *in situ*, are exposed. To this is due the appearance which M. DE BLAINVILLE was unable to understand in the figure above cited. "Ce que je ne conçois pas dans cette figure, c'est la manière dont les calottes empilées, qui constituent l'alvéole, dépassent de beaucoup la cavité de la coquille ou du tube, dont les bords sont cependant assez amincis pour croire que le péristome est parfait."—*Sur les Belemnites*, p. 95, 4to, 1827.

Fig: 1.



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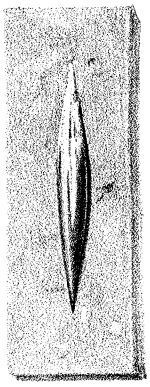

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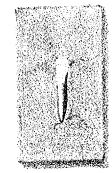

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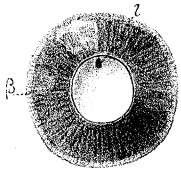

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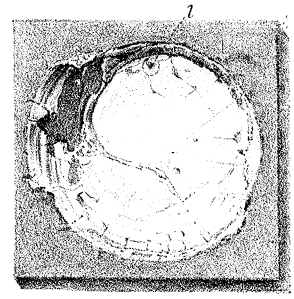

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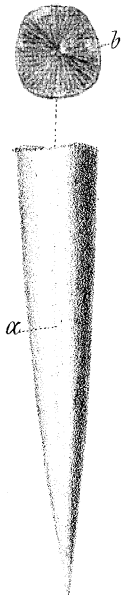

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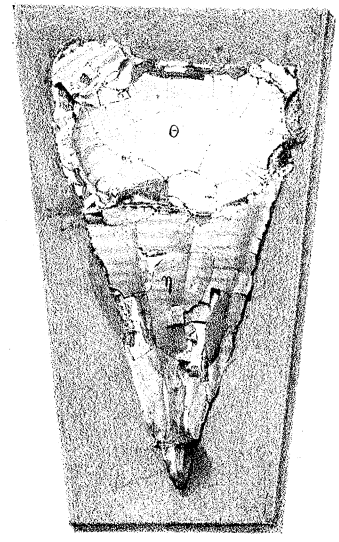
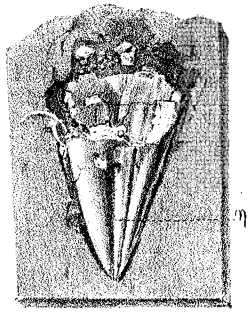


Fig: 6.



bottom not rounded, but defined by two parallel lines. The posterior half of the guard is slightly compressed laterally, and a very faint trace of a longitudinal impression may be discovered on each side, rather nearer the ventral than the dorsal surface. One of the specimens of the *Belemnites Owenii*, presented to the College of Surgeons by Mr. Broderip, measures eleven inches from the apex of the guard to the basal partition of the phragmocone: the diameter or breadth of that partition is one inch and a half: the length of the guard from its apex to the beginning of the crushed alveolus is six inches: the length of the ventral groove is one inch and a half.

With respect to the guard, I have little to add to the excellent descriptions of former authors, besides an account of its microscopic structure*: but this is the more requisite, as in some recent and estimable works the spathose structure is still regarded as the result of accidental posthumous infiltration. The guard consists of numerous, thin, for the most part concentric, layers† of minute prismatic trihedral fibres‡, placed at right angles, or nearly so, to the planes of the layers: the crystalline fibres are indicated by lines which radiate from the central axis and cross the lines of growth: the lines which define the fibres, when magnified 150 diameters, are seen in many parts of the section to run in pairs with a minutely and gently undulating course, resembling the tubes of dentine, but differing in the transparency of the intercepted calcareous matter, which is like that in the wider spaces separating the pairs of lines.

These differences in the intervals of the radiating fibres may depend on the different parts of the prismatic fibres divided in preparing the sections made parallel to their course.

There is an appearance not uncommon in microscopic sections of the spathose guard, which, though due to minute splintering or abrasion of the surface, is too characteristic of the texture of the guard to be passed over; it is produced by a number of elongated triangular specks§, defined by their opacity when the section is viewed by transmitted light, and by their white or silvery surface when viewed by

* This was first noticed by Dr. Carpenter in his valuable paper 'On the Microscopical Structure of Shells,' in the following words:—"The solid conical sheath of the Belemnite is a very favourable subject for microscopic examination; and of this I have made numerous sections. The greater part of these appear to have almost completely lost any indications of organic structure they may have once presented, being almost or completely homogeneous in their aspect. In some, however, I have met with a structure, which so closely resembles that of the massive *Septaria gigantea*, that I have no hesitation in the belief, that the shell of the latter is the nearest living analogue of the sheath of the Belemnite. I consider the term 'fibro-calcareous,' applied to the latter by Dr. Buckland, to be therefore erroneous; the structure being referable to the general type of membranous shells. The membrane seems to have been corrugated in a radiating direction, and as the deposition of calcareous matter followed the same, an appearance of radiating fibrous structure is given on fracture, which exactly corresponds with that of *Septaria*. The only difference between the two cases seems to have been, that, in the Belemnite the deposit took place from within outwards, whilst in the Septaria it was from without inwards."—*Extract from a Paper on the Microscopical Structure of Shells, by* William B. Carpenter, *M.D. Read to the Royal Society, December* 22, 1842.

† Pl. VII. fig. 1, β. ‡ Ib. fig. 1, γ; fig. 2, δ. § Ib. fig. 1, ε.

reflected light: the long axis of these triangles is always parallel to the fibres, and transverse to the layers; but on one side of the section the apices are turned towards the centre, on the other side towards the circumference of the guard; so that a slight change of focus reverses the position of the triangular specks.

The lines produced by the concentric layers of growth are seldom marked with equal distinctness; the strongest ones are usually in groups of three, five, or eight, with fainter lines in the clearer interspaces: this appears due to the varying thickness of the animal membrane at the contiguous surfaces of the layers of the prismatic fibres, which membrane was either formed by, or afforded attachment to the extremities of the delicate membranous cells which served as moulds for the calcareous matter of the fibres. The impress of these extremities has produced on many of the lines of growth a minutely undulating or crenate course. The layers of growth vary slightly in thickness; many are brought into view by applying a magnifying power of 150 diameters to a transparent section of the guard which otherwise would escape notice; those only being visible to the naked eye that are separated by the thicker lines; they are thus seen to be much more numerous than the septa of the phragmocone. In a transverse section through the middle of the alveolus, eighty layers could be counted in a thickness of a line, and more than three hundred in the solid part of a guard whose semidiameter was four lines.

A longitudinal section of the guard through its centre, and a transverse one, both demonstrate the longitudinal course of the radiating fibres, the linear indications of which might be interpreted as the folds of a plicated membrane: a longitudinal section taken near the circumference of the guard cuts across the radiating fibres, the extremities of which are thus seen in transverse section; their distinct and independent character and trihedral form are then clearly demonstrated, as in Pl. VII. fig. 2; they vary a little in size, the average diameter being $\frac{1}{2000}$th of an inch.

Through a great part of the thickness of the guard next the outer surface, the thin fibrous conical layers are concentric, progressively increasing in length as they approach that surface, and thus forming the alveolus or cavity for the phragmocone. The innermost or first-formed layers are not parallel with the outer ones, but recede from them at their anterior end, contracting as at the opposite end, but in a less degree, so as to form a slender cylindrical stem, sometimes slightly dilated at the end which is in contact with the apex of the capsule of the phragmocone. The interspaces thus left between the earlier and the later layers of the guard are occupied by more abundant animal membrane, mixed with coarser opake calcareous particles, like those which harden and render brittle the corneo-nacreous capsule of the chambers; a filamentary tract of the same kind of matter is continued from the apex of the above capsule down the centre of the guard to its posterior apex.

Mr. Pratt has obtained from the Oxford clay at Christian-Malford the guard of a young Belemnite, three lines long*, fusiform, slightly contracted posteriorly;

* Pl. II. fig. 4.

this must have belonged to an animal just excluded from the egg, if excluded at all. The layers of growth immediately added to this axis extend beyond it, both anteriorly and posteriorly; and, being thicker in the middle than at the two extremities, render the guard fusiform, as in the young specimen rather more than an inch in length* from the same stratum and locality as the preceding. At this stage of growth, which lasts longer in some species, as the *Belemnites subfusiformis*, than in others, the spathose guard has been mistaken for the spine of an Echinus, and this idea, first entertained of Belemnites in general by KLEIN, has been reproduced in later times by M. RASPAIL: even the sagacious Mr. MILLER†, who has done so much towards the elucidation of the Belemnites, was led to conceive the fusiform guard of immature individuals to be remains of a distinct genus, for which he proposed the name of *Actinocamax*‡.

The exterior surface of the spathose guard of the Belemnites of the Oxford clay, though smoother than in some other species, is minutely granular, and occasionally presents faint traces of vascular impressions, proving it to have been invested by an organized membrane of the living Cephalopod. On two specimens from this conservative stratum, I have detected remains of a more immediate investment of a thin friable layer of white calcareous matter, analogous to that of the outer layer of the sheath of the phragmocone. The animal membrane or constituent of the spathose guard has been alluded to by Dr. BUCKLAND as being evidenced by the odour resembling burnt horn, produced on burning this part of the Belemnite. I will only add in reference to the spathose calcareous constituent, that its microscopic structure proves it to be an original formation, deposited in membranous cellular moulds, under the influence of the vital organizing forces, and not to be the result of post-mortem infiltration of mineral substance, into an originally light and porous, or cellular texture, as WALCH, PARKINSON, LAMARCK and DE BLAINVILLE§ have conjectured.

As respects the phragmocone and its investing sheath, the well-preserved Belemnites of the Oxford clay demonstrate that the sheath is continued backwards to line the alveolar cavity of the spathose guard, as well as forwards from its basal outlet to form the visceral chamber anterior to the phragmocone. The phragmocone in these specimens appears broader than it actually was on account of the compression

* Pl. II. fig. 5.

† His conjectural figure of the recent Belemnite (Geological Transactions, new Series, vol. ii. (1826) Pl. IX. fig. 15) is essentially the same with those which have been since published by Dr. BUCKLAND, M. D'ORBIGNY and M. DUVAL-JOUVE.

‡ M. DUVAL (Mém. sur les Belemnites, 4to, 1841, p. 68) has demonstrated, what MM. DE BLAINVILLE and D'ORBIGNY suspected to be, the true nature of the *Actinocamax* of MILLER.

§ Sur les Belemnites, 4to, 1827, pp. 32, 33. Specimens of the spathose guard have been discovered which have been fractured during the life-time of the Belemnite, and healed; the broken portions having been held together by the surrounding organized integuments, and reunited by the deposition of new layers of the fibrous structure peculiar to the guard. DUVAL-JOUVE, Sur les Belemnites, p. 37, Pl. X.

which its frail walls have been unable to resist; its basal part is usually squeezed flat, but sometimes one of the septa has slipped forwards so as to present its surfaces to the planes of pressure, and so retain its original form: one of these, which shows likewise its natural slight concavity, demonstrates the marginal position of the siphon as in other Belemnites, Pl. II. figs. 3 and 7, *ι*.

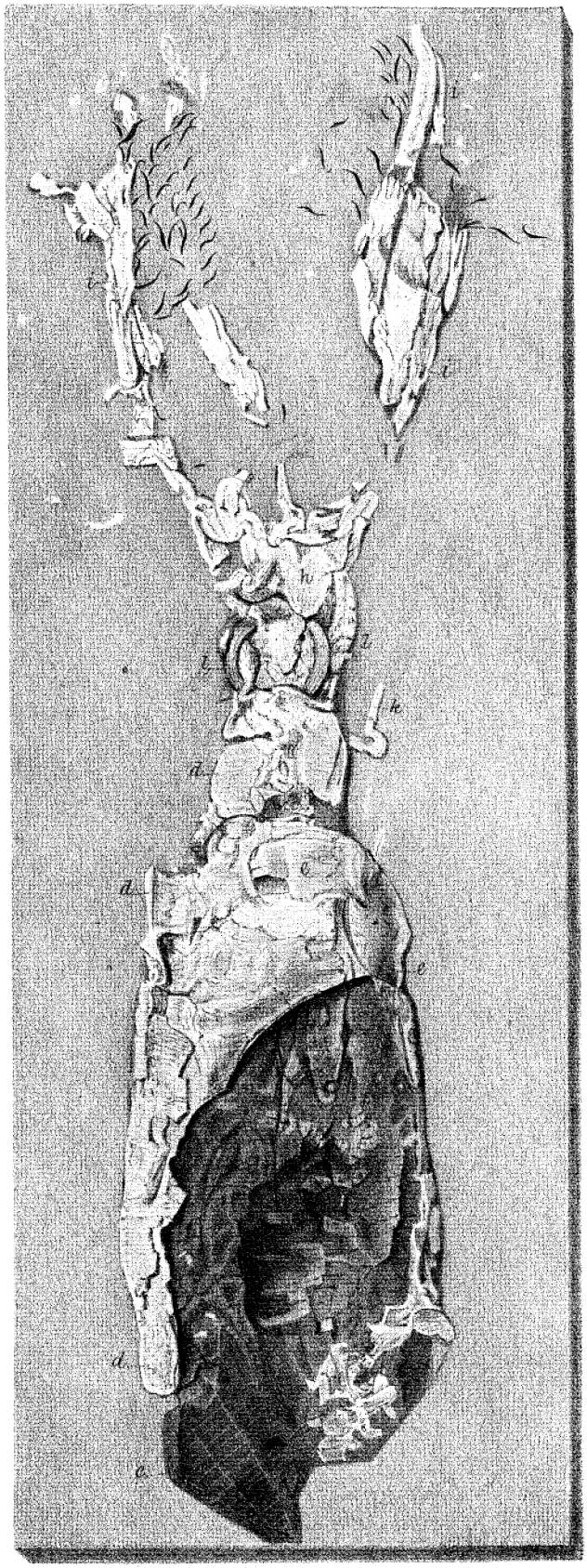
The septa are composed chiefly of nacre with a thinner layer of white friable calcareous matter on both surfaces, which is seldom preserved. I have found twenty septa in an extent of two inches from the base of the phragmocone; about an equal number of septa dividing chambers progressively diminishing in depth, and more rapidly in width, are indicated, by detached phragmocones, to have extended to the apex of the socket of the guard. The capsule of the phragmocone consists of a thin layer of mixed albuminous and opake calcareous matter, lined with nacre, but with a yellowish smooth outer surface. In Lord NORTHAMPTON's well-preserved specimen, it terminates by a well-defined margin a little in advance of the ink-bag, forming there the true peristome of the shell, as shown in fig. 9.

The entire phragmocone, with its capsule, of these Belemnites from the Oxford clay, has been found not unfrequently isolated and detached, having slipt out of the alveolar cavity of the guard; such specimens are squeezed flatter than those which have remained in and been protected by the guard. The yielding texture of the phragmoconic capsule has commonly caused it to fall into longitudinal folds when compressed, after having become detached from the alveolus. In two specimens in the collection of Mr. CUNNINGTON of Devizes these folds are well-marked, regular, and on the same side of the capsule, forming two longitudinal grooves* in one and three in the other, the intermediate risings being so well defined as to appear like a structure original and natural to the capsule; but their position is different, and the degree of the indentation varies, and in other specimens the partial longitudinal impressions are barely discernible. If the change of form caused by the compression were not borne in mind, these piles of concave plates would seem not to have been adapted to the alveolus, and might thus be made occasions for the revival of the exploded idea of DE MONTFORT, that the phragmocone of the Belemnite belonged to an animal generically distinct from that which had constructed the spathose guard.

Belemnites whose remains have been left in strata percolated by streams containing mineral matter in solution, have the chambers of the phragmocone filled with crystals consequent upon such calcareous or siliceous infiltration: in the present Belemnites from the Oxford clay, no such infiltration has taken place subsequent to interment; we find only the delicate original calcareous framework of the phragmocone, crushed and squeezed out of its original shape, whilst the solid part of the spathose guard, by virtue of its proper primitive fibrous structure, has retained its cylindrical figure. This fact, independently of the microscopic evidence of organiza-

* Pl. II. fig. 6, *η*.

Fig: 1.



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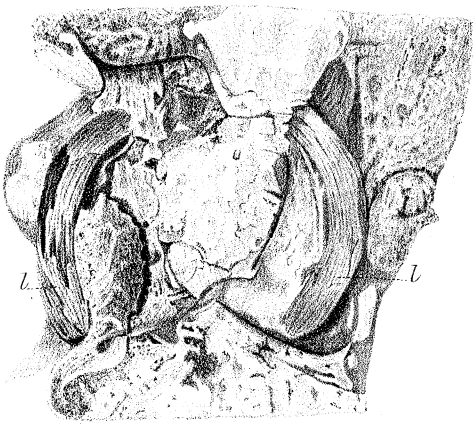

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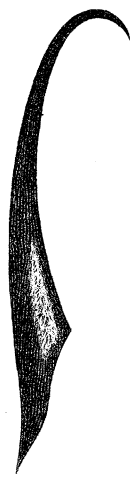


tion, suffices to prove that the weight and solidity of the guard had received no augmentation by inorganic influences after death*.

That the shell of the Belemnite was due to the formative forces of the mantle of a molluscous animal, was the sound speculation as to its nature, which our countryman Joshua Platt first recorded in the Transactions of the Royal Society for 1764. The presence of a camerated and siphonated structure in this complicated shell, led Walch† and Guettard‡, and after them most subsequent conchologists, to class the Belemnites with the Baculites, Orthoceratites, and other more simple chambered shells. Mr. Miller, having detected evidence of the internal position of the belemnitic shell, compared it, as Deluc§ on other grounds had done, with the internal shell of the Cuttle-fish, and first ventured on a conjectural restoration of the entire animal. He thought the Belemnite to have been an intermediate form in the Cephalopodal class, uniting the internal multilocular shell of the *Spirula* with the laminated calcareous plate of the *Sepia*, to which the belemnitic guard appears to correspond; and, believing that the *Nautilus*, *Ammonite*, *Sepia* and *Loligo*, had the same organization (only the *Dibranchiate* type of Cephalopodal structure being then known), Mr. Miller placed the belemnitic shell in the body of a Calamary (*Loligo*), assigning to the terminal fins the office of clasping the guard and retaining it in its proper position; which last idea M. De Blainville very justly rejected.

The subsequent discovery of two grades of organization in the class of Cephalopods, consequent on the dissection of the *Nautilus Pompilius*‖, called for a closer investigation of the affinities of the Belemnites, and led to an attempt to establish a more definite approximation of these with the other families of siphoniferous Cephalopods, now ranked under two distinct orders of the class.

The first evidence that bore directly upon the question of the position of the Belemnite in this class, was detected by Dr. Buckland¶ and M. Agassiz** in specimens of Belemnite from the lias at Lyme Regis, in which the fossil ink-bag was preserved in the basal chamber of the phragmocone, or that formed by the anterior prolongation and expansion of its capsule.

The importance of this discovery depends chiefly on the facts, that the secreting gland and reservoir of the inky secretion common to all the naked Cephalopods do not exist in the recent *Nautilus Pompilius*, and that no trace of them has ever been

* Such was Mr. Miller's opinion; but, as it was unsupported by microscopic investigation, or by any facts like that above cited, it was not accepted by Prof. De Blainville and Dr. Buckland.

† In Knorr's 'Recueil de Monumens des Catastrophes que le Globe de la Terre a essuyeés,' &c. fol. 1768.

‡ Mémoires sur différentes parties des Sciences et des Arts, t. v. 9e Mémoire, 1783.

§ Mémoires sur les Bélemnites, in Journal de Physique, 1799, 1801, 1802.

‖ Owen, Memoir on the Pearly Nautilus, 4to, 1832.

¶ Philosophical Magazine, N.S. 1829, p. 388. [One of the specimens discovered by Miss Mary Anning of Lyme, on which Dr. Buckland's observations were made, has been presented, since the reading of the present memoir, by the Earl of Enniskillen to the College of Surgeons.]

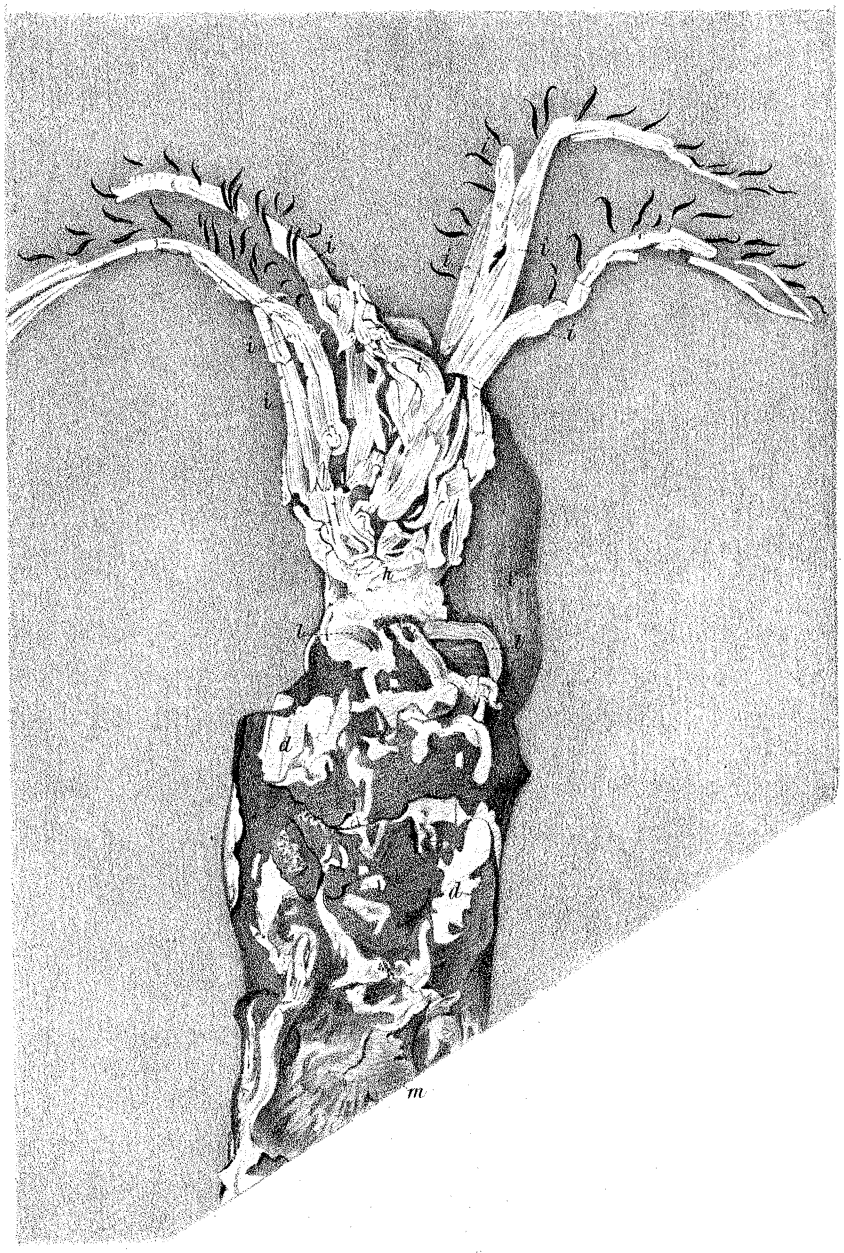
** Ibid. 1834.

met with in connection with any of the simple or typical forms of fossil chambered shells, as the *Orthoceratites*, *Baculites*, *Ammonites*, &c.

Reflecting on this marked difference in the anatomy of the Nautilus, I was led to perceive that, as this rare Cephalopod derived sufficient protection from its large and strong external shell, it might well dispense with that peculiar glandular apparatus which had before been deemed a common character of the Cephalopodal class; whilst on the other hand, as the highly organized naked Cephalopods enjoy active powers of locomotion which would be incompatible with the incumbrance of a heavy external testaceous defensive covering, they required a compensatory endowment of the power of secreting an inky fluid, which, when alarmed, they might inject into the surrounding water and conceal themselves by the dusky cloud thus occasioned. But the branchial character of the naked order of Cephalopods is an essential condition of their muscular powers; the presence of an ink-bladder, therefore, in the extinct Belemnites, would have implied the internal position of the shell, even if other proof had been wanting; and, by the laws of correlation, it implies likewise the presence of the muscular forces for rapid swimming, and the concomitant conditions of the respiratory, the vascular and the nervous systems. Connecting, therefore, all these considerations with the detection of the ink-bag in the shell of the Belemnite, I felt justified in referring the Belemnites, and likewise the Spirula, on account of the ascertained internal position of its shell, to the Dibranchiate order; and I therefore separated these chambered and siphoniferous shells from the Nautilus and the Ammonites, in the classification of the *Cephalopoda* submitted to the Zoological Society in February 1836*.

But the true grounds of this separation seem not to have been appreciated or understood by some Palæontologists. Professor PHILLIPS, for example, in his excellent article on *Turrilites*, in the part of the Penny Cyclopædia published in January 1843, has observed, "The relations of Turrilites, Scaphites, Baculites and Hamites to Am-

* Zoological Transactions, ii. pp. 127, 129. "The *Cephalopods* with internal chambered shells, heretofore classed with the *siphoniferous Cephalopods*, which constitute the preceding order, I would join with all the other *naked Cephalopods*, to form a second order, under the term *Dibranchiata*, having reference to the number of gills, viz. two. This number is constant in all the '*Seiches*' of CUVIER, and is associated with the presence of two branchial hearts, besides the single systemic heart, and with an ink-bag: there can be little doubt that the same type of structure is exemplified in the *Spirula*, from what has been determined respecting its external characters[3]." [3] "The discovery by Dr. BUCKLAND of the remains of the ink-bag in the extinct *Belemnites*, justifies the conclusion from the laws of coexistence, that these *Cephalopods* also possessed two gills and two branchial hearts." In the same year, 1836, the Number of the Cyclopædia of Anatomy and Physiology was published, containing my Article '*Cephalopoda*,' in which it is argued of the *Belemnites*:—"As it is certain that the animals of this family of extinct *Cephalopods* possessed the ink-bag, they must consequently have been enveloped by a muscular mantle; and we may, therefore, infer that they resembled the *Dibranchiates* in their locomotive and respiratory organs, and consequently in the general plan of their organization. In the structure and position of their siphoniferous camerated shell, they are intermediate to *Spirula* and *Sepia*, and as the animal of *Spirula* is proved to be a *Decapod*, the probability is very strong that the animal of the *Belemnite* was of the same type."—p. 520.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monites is very obvious; and, as through Goniatites, this great extinct group is certainly connected to the living and extinct *Nautili*, Mr. Owen has ventured to include them all in the Tetrabranchiate Cephalopoda, leaving Spirula and the Belemnites with Sepia and the Dibranchiate types. However this may be, the determination of the relative affinities among the numerous fossil Cephalopods, a point of great importance, must be worked out with the help of other considerations than the respiratory system." In the memoir on the 'Classification of *Cephalopoda*,' above cited, it will be found that many other considerations than those of the respiratory system, and of equal importance with them, influenced me in forming an opinion of the natural position of the Belemnites in the class *Cephalopoda*.

Leopold Von Buch, who believed that he could trace in certain slabs containing Belemnites the impressions of the Cephalopods to which they belonged, concluded "that the body of the animal enveloped the greater part of the shell, and exceeded its length by eight or ten times*." Other considerations taken from the shell itself prove, as has already been shown, that it was wholly internal.

The specimen† presented to the Hunterian Museum by the Marquess of Northampton, exhibits the phragmocone, the muscular mantle, a small part of the head, and a greater or less proportion of six of the cephalic tentacula which are armed with horny hooks in a double alternate series, as in the *Onychoteuthis gigas*.

The phragmocone with the soft parts of the Belemnite has been detached from the guard probably soon after death; and the whole squeezed nearly flat after becoming interred in the laminated clayey matrix. The resistance of the ink-bag (*n*) with its inspissated and indurated contents, has led to abrasion and loss of the walls of the part of the phragmocone covering it, and it seems to have been pressed downwards through one or two of the basal partitions deeper into the sheath than was natural, or than it is situated in other specimens. The capsule of the phragmocone extends about one-third of an inch beyond the ink-bag, and terminates by a well-defined border. The smooth surface of its opake white external calcareous layer is well preserved over nearly the whole of this part. The muscular tunic of the mantle (*d*) appears to commence at the peristome; it seems to have first undergone the change into adipocire and then to have become so brittle as to crack and break instead of bending to the pressure; the course of the muscular fibres is plainly visible; all those on the outer surface of the mantle which is presented to the observer, are transverse or circular; this surface is smooth, and the course of the fibres more feebly indicated; in the few places where the upper side of the mantle is broken away, and the inner surface of the opposite side shown, the arrangement of the transverse fasciculi is more strongly displayed.

In the length as compared with the breadth of the mantle, the Belemnite is shown by this beautiful specimen to have had the same elongated form of body as the *Onychoteuthis* and most modern *Decapoda*.

* Oken's Isis, Bd. xxi. p. 438.

† Pl. III.

A little above the capsule of the phragmocone, on the left side, there is a flattened transversely fibrous body (*e*) with a rounded external border, so well defined as to excite the suspicion that it must have belonged to some part superadded to the muscular mantle; its nature is demonstrated in the specimen next to be described.

An oblong portion of the same fibrous and muscular tissue as the mantle, lying obliquely in front of the anterior margin of the mantle, and in which both a longitudinal and transverse layer of fibres are discernible, seems to be the remains of the infundibulum or expiratory tube (*f*).

The direction of the fibres in the cephalic arms is chiefly longitudinal; the magnified figure* precludes the necessity of describing the shape of the horny hooks; their arrangement in a double alternate series is manifested in some parts of the arms, but is still more obvious in the third specimen† to be described.

The second less complete but highly instructive specimen of the Belemnite‡ is from the collection of Mr. PRATT; it exhibits part of the muscular mantle (*d*), the two fins (*e*, *e*), apparently the infundibulum (*f*), the ink-bag and duct (*n*), and a considerable proportion of the phragmocone (*c*). This part is more distorted and less entire than in the preceding specimen, but, so far as a comparison can be made, presents the same form and structure§.

The reservoir of ink is situated two lines within the aperture of the phragmoconic capsule, which terminates with the same well-defined border; it is of an oval form and jet black colour, with a feeble indication of its original nacreous outer coating: the inspissated ink is very hard, brittle and splintering; when reduced to a fine powder it presents a dark brown hue, and, used as a pigment, works as smoothly as Roman Sepia, but with a deeper tint.

The Belemnitic ink-secretion offers the closest resemblance with that described by Dr. BUCKLAND from the lias of Lyme Regis, and which he found associated with a series of circular transverse plates and narrow chambers, resembling the chambered cone within the alveolus of a Belemnite, and from which Dr. BUCKLAND inferred that the animal, from which these fossil ink-bags were derived, was some unknown Cephalopod, nearly allied in its internal structure to the Belemnite, the circular form of the septa showing that they could not be referred to the molluscous inhabitant of any Nautilus or Ammonite‖.

The absence of the ink-apparatus in the Nautilus and allied extinct chambered Cephalopods adds demonstrative proof, were such required, of the accuracy of Dr. BUCKLAND's negation, whilst the association of the spathose guards with crushed phragmocones, identical in structure with those in connection with the fossil ink-bag and muscular parts of the specimens under consideration, and all from the same

* Pl. IV. fig. 2. † Pl. V. ‡ Pl. IV. fig. 1.

§ Near the confused remains of the head in this specimen there is the impression of part of the phragmocone of another Belemnite.

‖ Philosophical Magazine, 1829.

Fig: 2.

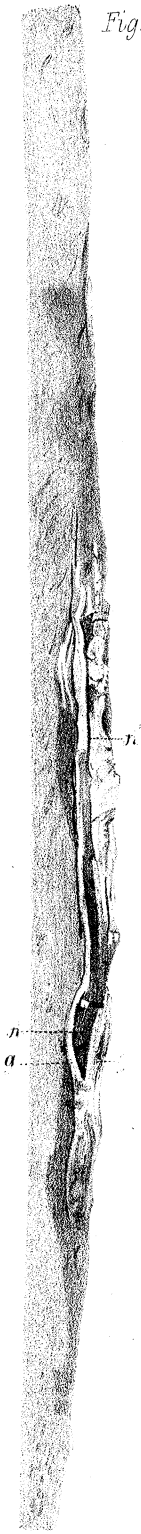
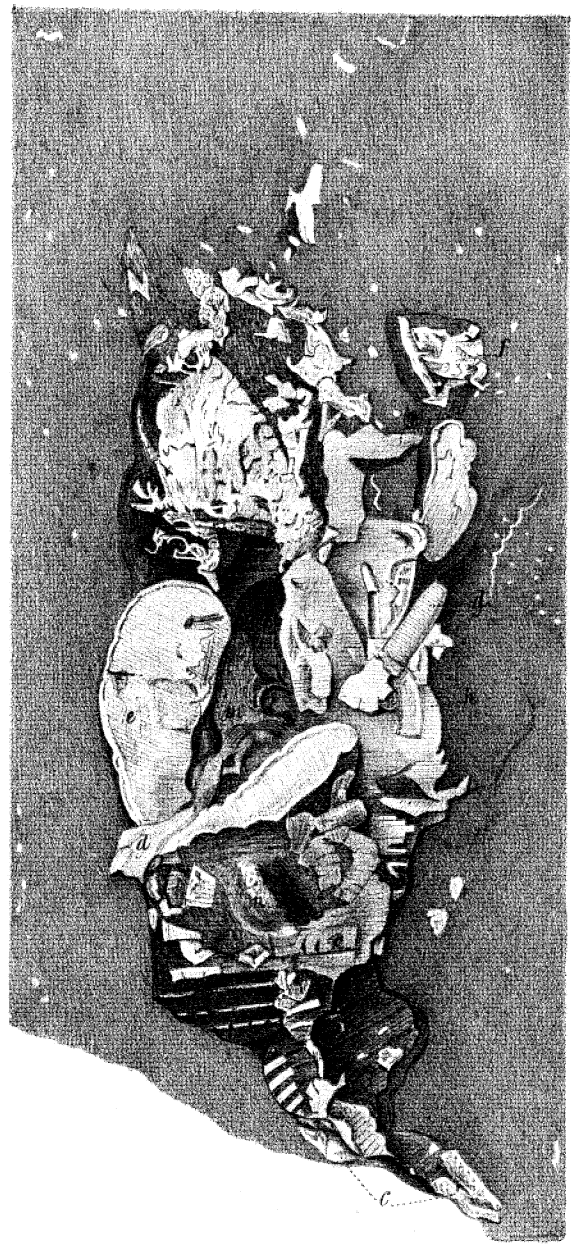


Fig: 1.



J. Basire, Zincog:

stratum and restricted locality, admits of no reasonable doubt of their belonging to one and the same species of true Belemnite.

The two flattened fibrous bodies, (*e*,*e*) with well-defined semi-oval external and apparently free margins,—the one on the right side entire, the one on the left having the contour of the defective part of the margin indicated by the dark carbonaceous stain in the matrix,—are the parts which I regard as the lateral fins of the mantle. They have been slightly displaced transversely and pressed inwards upon the yielding viscera; their original cartilaginous basis would favour their encroaching in that direction if subjected to equable surrounding pressure: the lateral fin which is preserved in the first specimen* has been pushed more deeply inwards.

The large end of the semi-oval free border is the anterior one, where the fin is broadest; it gradually becomes narrower posteriorly. The muscular fasciculi are strongly marked, and are arranged transversely to the long axis of the fin, as in existing Decapodous Cephalopods. It is interesting to find a rounded contour associated with an advanced position of the lateral fins in the ancient Belemnites, as in the modern *Rossia* and *Sepiola*, the rhomboidal form being most common in those fins which are placed at the end of the body, as in the Onychoteuthis and Loligo; the only exception, indeed, being presented by the *Loligopsis*, which has terminal and rounded fins.

M. Duval, the latest and most accurate author on fossil Belemnites, reproduces† the figure which M. D'Orbigny has published, and which is essentially the same as that given by Dr. Buckland in his Bridgewater Treatise; and, like it, differs from Mr. Miller's restoration, in the position of the ink-bag and in the extended state of the terminal fins. With respect to these parts, M. Duval, from his discovery of the united fractures of the spathose guard, has objected with much acumen, that, if the fins of the Belemnite had been placed at the side of the guard, they must have been rendered useless by its fracture, and the creature, thus deprived of its power of swimming, would soon have fallen a prey to its numerous enemies, and would not have survived to exemplify the reparative powers of those ancient Cephalopods. M. Duval, however, modestly concludes by confessing that he should not have dared himself to figure from the known analogies, the animal to which the Belemnite ought to have belonged; for "I have not," he says, "a sufficiently exact knowledge of the organic laws of the Cephalopoda." It seemed vain to hope that the soundness of the principles on which the classification of the Belemnites with the dibranchiate Cephalopods had been definitely proposed, should ever be vindicated by the demonstration of parts, apparently so perishable as the fleshy mantle, the fins, and the slender flexile arms of these ancient Mollusca‡.

* Pl. III.

† Sur les Belemnites, 4to, Pl. 7. fig. 10.

‡ Cuvier, in the second edition of the 'Règne Animal,' places the *Belemnites* between the *Orthoceratites* and the *Ammonites*, and observes, "*ils appartiennent probablement encore à cette famille, mais il est impossible de s'en assurer, puisqu'on ne les trouve plus que parmi les fossiles*," tome iii. p. 19,—which teaches how liable the best authorities are to err, when they would set bounds to the possibilities in Nature.

But we derive from the present remarkable specimens ample confirmation of the association of the ink-bag with the higher grade of the circulating and respiratory organs, which grade is necessarily associated with the high development of the locomotive system, as demonstrated by the muscular mantle and its appended fins; whilst the preservation of the latter organs *in situ* establishes the soundness of M. Duval's objections to their position in all the published conjectural restorations of the Belemnite.

In the specimen under consideration* the fins are crossed by a narrow tract of grey transversely fibrous substance, probably part of the mantle, near the anterior termination of which an oblong flattened tract of similar substance extends forward, slightly expanding as it advances to a position opposite the neck of the Belemnite, where it is terminated by a slightly concave truncation: longitudinal fibres may be discovered decussating the more abundant transverse fibres of the part which is most probably the remains of the infundibulum. A short flattened band of fibres (*g*) connects this part with the neck of the Belemnite, having the exact position and proportion of the retractor or levator muscles of the infundibulum of the naked Cephalopods†. The traces of muscular tissue in the situation of the head are much more obscure: two short processes from the anterior part of this mass are evidently the bases of tentacula or cephalic arms.

At the middle of the visceral mass, in the interval of the two lateral fins, there lies a compressed body of a horny texture and sub-bilobed form (*m*), on which may be clearly distinguished striæ passing outwards in opposite directions from a middle line and diverging from each other in their course, which resembles that of the fibres of the digastric muscle in the gizzards of the Nautilus and other Cephalopods: this apparent remnant of the stomach lies about half an inch in advance of the ink-bladder, in a position corresponding with that of the gastric organ in naked Cephalopods.

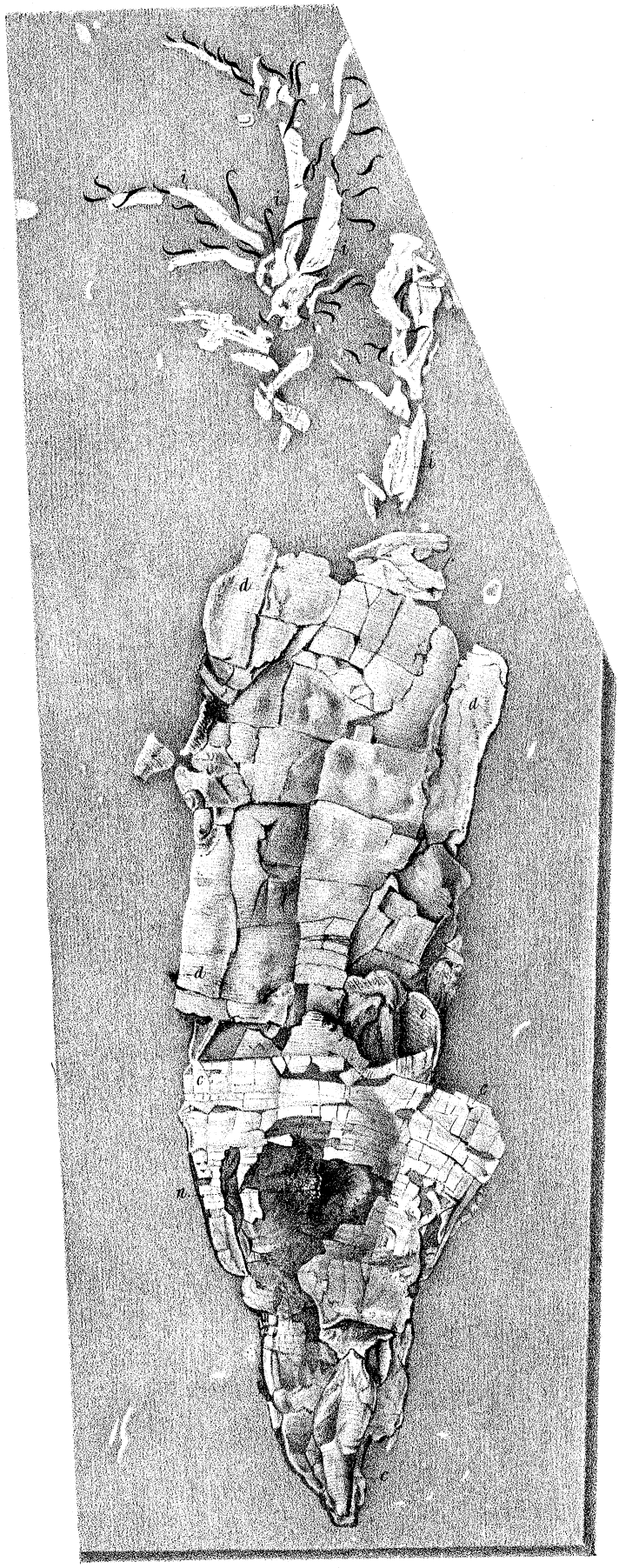
There is strong negative evidence that the Belemnite possessed horny mandibles like the other naked Cephalopods, since no calcareous beaks, or Rhyncholites, have been discovered associated with the specimens from the Oxford clay, or with those from the lias.

The thickness of the layer of dried and compressed grey fibrous matter to which the mantle is reduced is half a line, and we may infer from this, that in its soft and recent state, when permeated by its sanguiferous vessels, it must have equalled in thickness that of a Calamary of the same size. In fact the mantle of true *Teuthidæ* (Calamaries with horny pens), preserved in the same matrix as the Belemnites here described, has been reduced to a compact fibrous layer of the same thinness: a specimen of one of these‡ displays by a fracture of the layer of the clay in which it was imbedded, the anterior and posterior walls with the intervening cavity of the abdomen, exposing the ink-bag and duct *in situ*.

* Pl. IV. fig. 1.

† Compare fig. 10, *g*, with Cuvier's Pl. 1. fig. 2, *m*, *n*, Mémoire sur le Poulpe, 4to.

‡ Pl. IV. fig. 2.



J. Basire, Lincoln.

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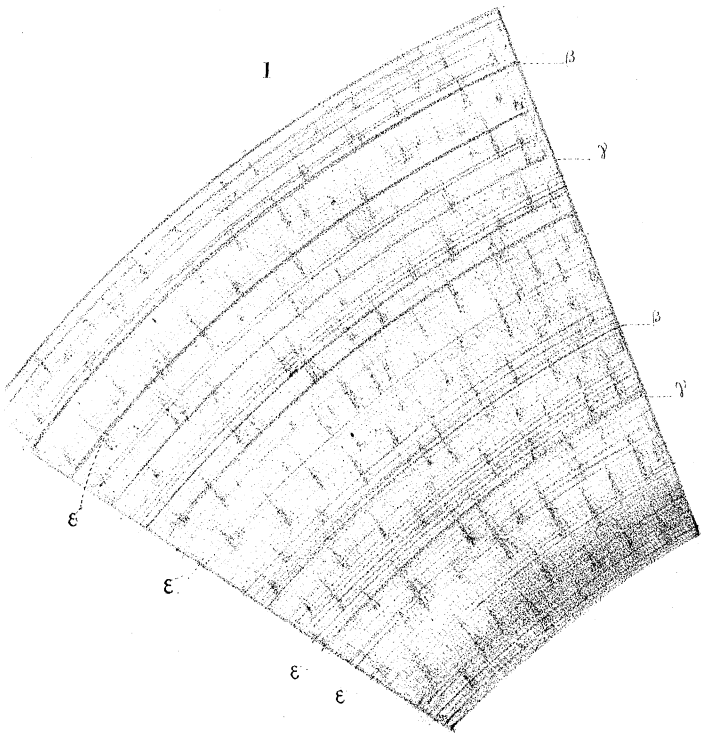

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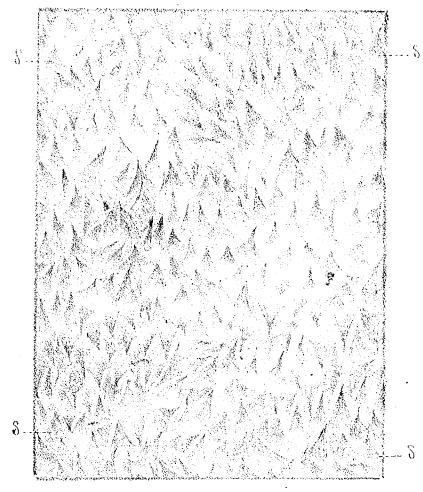

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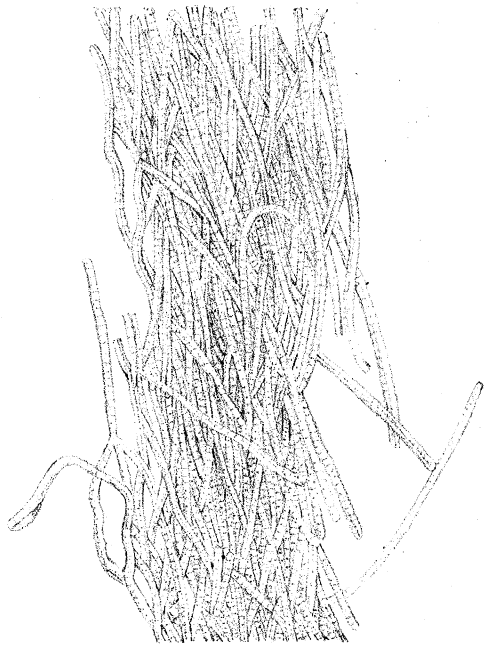

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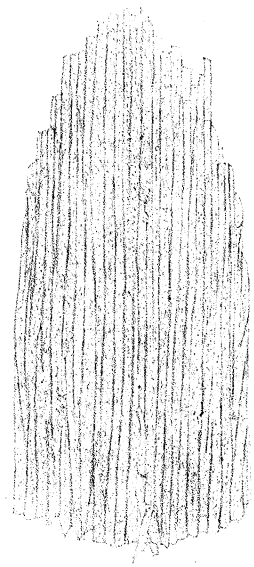


Lens Aldous, del. et Zinc.

J. Basire, Zincog:

Microscopic structure of the guard and Muscular fibre.

In neither of the above described specimens of Belemnite having the soft parts and phragmocone in natural connections, is there any evidence of the muscular part of the mantle having been continued over the capsule of the phragmocone; it is traceable for a short way below the peristome in Mr. CUNNINGTON's specimen*; but it is best developed where it surrounded the compressible part of the body of the Belemnite anterior to the shell. There seems no reason, however, to doubt that the skin, which, in existing naked Cephalopods is thin and lubricous, and more easily detached from the subjacent muscular layer than in the lower Mollusks, was extended over that part of the phragmocone extending beyond the alveolus, as there has been already shown evidence of its continuation over the alveolar and solid part of the spathose guard: its gelatinous base was less favourable for preservation than the fibrinous nature of the muscular tunic, and its destruction is, therefore, not surprising. The dark stain upon the clayey matrix, which usually extends a little beyond the preserved muscular structure, may in part be due to the pigmental cells of the skin; and these seem evidently to have produced the thin crust of a dark greenish colour which hides part of the fibrous layer of the mantle in the third specimen left for description.

This†, which is from the collection of Mr. PRATT, is chiefly remarkable and valuable for the perfect conservation of the complex muscular structures of the head and its uncinated arms. Eight of these, forming the normal series of cephalic arms, may be defined, radiating from a contracted base. In this base may be observed two decussating groups of curved fibres (*h*), the posterior one with its concavity turned towards the mantle, the anterior one with its concavity directed forwards, and its horns continued into the bases of the arms. A similar decussated arrangement of fibres exists in the *Onychoteuthis*, and is described and figured by CUVIER in the corresponding part of the head of the *Octopus*. Almost the entire extent of five of the cephalic arms is preserved, as shown in the figure; they are rather longer in comparison with the mantle than in the modern Onychoteuthis, but not as compared with the entire body of the Belemnite when this is lengthened out by the terminal spathose guard: the longitudinal arrangement of the fasciculi of muscular fibres of the arms is very distinct.

I placed a portion of the muscular tissue under the microscope, and succeeded by the aid of a drop of diluted acetic acid in softening and unravelling the constituent fibres‡; they presented the same size as the fibres from the corresponding part of one of the arms of an *Onychoteuthis*, but the faint transverse striæ visible in the recent fibre§ had disappeared in the fossil, and only an obscure granular structure could be discerned.

Each of the arms seems to have been provided with from fifteen to twenty pairs of hooks‖, which were doubtless developed from the horny hoops which encircled the caruncles of the acetabula, as in the modern *Onychoteuthis*.

* Pl. VI. fig. 1, *d*. † Pl. V. ‡ Pl. VII. fig. 4. § Ib. fig. 3.

‖ Pl. VI. fig. 2, is a magnified view of the most perfect of these hooks.

Two small protuberances at the origin of the normal brachia are the only parts which represent the bases of the pair of long tentacula, superadded to the eight shorter arms in the existing *Decapoda*.

On each side of the head, behind the bases of the arms, there is a convex protuberance formed by a well-defined semicircular band, about a line in thickness, of grey fibrous matter, the fibres or layers being parallel with the curve of the band. These parts are more distinctly shown in Mr. CUNNINGTON's specimen, in the description of which the reasons for regarding them as belonging to organs of vision are given. In the present specimen they indicate, according to this view of their nature, that the eye-balls of the Belemnite were sessile*, and agreed in size, as in position, with those of the modern naked Cephalopods.

Another specimen of similar size, in the collection of Mr. PRATT, exhibits the upper two-thirds of the visceral cavity formed by the mantle and the head with the bases of the arms, one of which is preserved to the extent of two inches, another to that of one inch, and on both these a few of the horny hooks remain. At the lower part of the head a circular amorphous granular mass is visible; it is bounded anteriorly by a curved fasciculus of fibres with the concavity directed backwards: above these the fibres which are continued into the bases of the arms commence from a fasciculus curving in a direction opposite to the preceding. These decussating bands are similar to those in the former specimen but are more strongly marked. The fibres continued into the arms are chiefly longitudinal. The few hooks which are preserved in this specimen are identical in size and shape with the more perfect series in the preceding specimen.

There is a minute trace on the left side, near the lower end of the specimen, of an obliquely striated horny plate. Most of the preserved fibrous structure of the flattened mantle is transversely arranged, as in all the other specimens; but a faint trace of longitudinal or retractile fibres may be discerned near the anterior margin of the mantle.

The fracture of the slabs of clay containing the last two instructive specimens has crossed obliquely that part of the abdomen in which is situated the striated thin horny plate, agreeing with that which I have ascribed to the gizzard: wanting therefore both the ink-bag and phragmocone, these specimens were defective in the requisite evidence to associate the uncinated arms with the complex shell, muscular mantle, and rounded fins of the Belemnites.

The coexistence with the true Belemnites, in the Oxford clay at Christian-Malford, of fossil Calamaries with a dorsal horny gladius or pen, like those from the lias at Lyme Regis described by Dr. BUCKLAND†, made it still more desirable to obtain such evidence as could only be given by more entire specimens of those ancient uncinated Cephalopods than those above described from the collection of Mr. PRATT, which were the first and for some time the only specimens of the kind that I had seen.

The subsequent fortunate discovery of the unique example‡ submitted to my ex-

* In the *Nautilus* the eyes are pedunculated. † Bridgewater Treatise, i. p. 308. ‡ Pl. III.

amination by the noble President gave the much-desired solution to the question; the form of the muscular part of the mantle, the proportions of the arms, and the number, shape and disposition of the horny hooks, being identical in that specimen of the Belemnite with those in the beautiful one with the crown of uncinated tentacles formerly in Mr. PRATT's cabinet, and now deposited, with the more perfect Belemnite from Lord NORTHAMPTON's collection, in the Hunterian Museum.

I have more lately been favoured by Mr. CUNNINGTON of Devizes with the temporary possession of the instructive specimen* of the *Belemnites Owenii* obtained from the same stratum and locality as the foregoing. It exhibits a considerable proportion of six of the cephalic arms; one of them is three inches and a half in length, but not entire; a full inch of another is indicated or represented by the double series of hooks, in their natural relative position, there being ten pairs in this extent.

The muscular tissue, forming the common base of the arms (*h*), has been preserved in a more compact mass than in Mr. PRATT's specimen, but the arrangement of the fibres is distinguishable. A median fine groove may be traced along each of the best preserved arms, indicating the cavity in which the artery and nerve were lodged.

From near the side of the common uniting base of the ordinary uncinated arms a long and narrow tract of fibrous matter (*k*) bends down along the side of the head to the beginning of the mantle, becomes more slender than the cephalic arms, and is reflected, with an irregular twist, forwards again; this is obviously the basal part of one of the long superadded tentacles.

The most marked and peculiar character of the present specimen is seen in the part of the head immediately behind the base of the arms; at this part, imbedded in the usual grey remains of the muscular tissue, are two semicircular portions of a denser and darker greyish brown fibrous substance (*l l*), obviously the same parts as those above described and referred to the eyes, in Mr. PRATT's second specimen†; the parts in question are regularly placed in reference to each other in the present specimen, being on the same transverse line, with their concavities towards each other, and their convexities turned outwards: each body is a line in breadth and does not diminish at either extremity, which is lost in or hidden by the surrounding muscular tissue: their structure is more minutely but more definitely fibrous than in the muscles, the fibres following the curve of the band. The parts in existing Cephalopods, which first suggest themselves for comparison with these, are, the beak, the cartilage of the head, the cornea or the crystalline lens. The position of the curved fibrous bodies is posterior to that in which the beak should be placed, agreeably with existing analogies; the texture of the beak, also, in the *Onychoteuthis* is the same as that of the hooks, whilst that of the parts in question is very different from the black horny matter of the preserved hooks. The position of the parts in the present specimen, like that in Mr. PRATT's, corresponds with that of the large sessile eyes, only that they

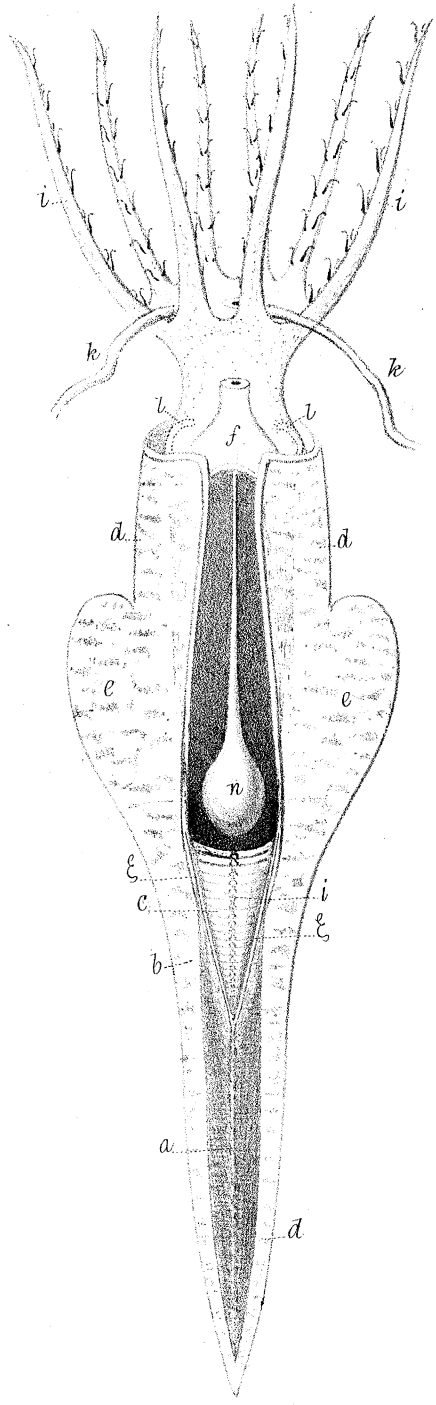
* Pl. VI. fig. 1. † Pl. V.

are more nearly approximated towards each other. In reference to the large crystalline lens which characterizes the eye in naked Cephalopods, the parts in question can only be compared, from their size, with the exterior laminæ of the outer division of the lens, in which case the larger and denser inner division of the lens has not at all been preserved; which is by no means a probable occurrence, and induces me to reject this analogy. If we compare them to the strong external tunic of the eye, their outward convexity would lead to their being referred to the cornea. But this part, in all existing Cephalopods is a modification of the integument, and continuous with it, presenting a less degree of convexity than in the fossils, less thickness, and a less definite extent. Viewing, however, the relative position, form and structure of the parts under consideration in the two specimens in which they are preserved, the most probable conclusion respecting their nature appears to me to be that which refers them to the anterior or external tunic of the eye-ball, in which case they indicate a thicker, stronger, more distinct, more extensive, and more convex cornea in the Belemnite than in any known existing Cephalopods.

Just behind the eyes is an oblong body in which a fine longitudinal arrangement of fibres is visible; this may be the remains of the funnel: in the adjoining part of the mantle the transverse fasciculi are, as in the other specimens, plainly discernible. The left fin (*e*) is well preserved, and the contour of part of the right fin, as it seems to me, is traceable, folded back upon the mantle. The left fin presents exactly the same relative size and semi-oval contour of the free margin which is shown in Mr. Pratt's specimen; it has been slightly displaced, and advanced obliquely near the anterior border of the mantle. A very compact shining dark-coloured substance at the detached basal margin of this fin may be the charred remains of its supporting cartilage. The right fin, the free border of which is bent inwards upon the mantle, as is not unusually seen in ordinary naked Cephalopods, has preserved its true position, rising a little above the visceral chamber of the phragmocone. The most important additional fact which we derive from the present specimen is the continuation of the mantle over the sheath of the phragmocone, proving indisputably the internal position of that part. The chambered division and thin calcareous and nacreous structure of the crushed remains of the phragmocone are quite identical with those of the phragmocones preserved with the spathose guard in the specimens from Mr. Pratt's and Mr. Broderip's cabinets.

In the present specimen about one inch of the apex of the phragmocone has been separated from the rest, but its impression is distinctly preserved: in this we may trace the longitudinal fold of the crushed capsule, and the impressions of the chambers and septa to within a few lines of the apex. At the anterior part of the phragmocone we have the depression in which the ink-bag with its indurated contents was lodged. Remains of a thin horny plate are situated anterior to the ink-bag.

The evidence afforded by the above-described specimens of the paucity in number and superiority in size and complication of the cephalic tentacles of the Belemnite,



Belemnite restored

J. Basire, Zincog.

as compared with those of the Nautilus, yields another proof of the constancy of the laws of organic correlation; the very numerous, small, and comparatively simple tentacula of the Nautilus, which illustrate the principle of vegetative or irrelative repetition, being associated with an essentially inferior type of Cephalopodal organization, into which an internal shell, a thick muscular mantle, pallial fins, and an ink-secreting apparatus do not enter.

The cephalic arms of the existing species of Onychoteuthis present at the present day the highest grade of organization that has been observed in these characteristic prehensile instruments of the Cephalopoda. The great specimen captured by Banks and Solander off Cape Horn in the first voyage of Captain Cook, offers the best example of this formidable prehensile structure, since, not only were the extremities of the two long tentacula beset with hooks, but all the eight normal arms supported a double alternate series of uncinated acetabula.

But in comparing the different forms of Cephalopods that have successively appeared and perished since the deposition of the lias to the present time, we do not find that the above most complex organization of the cephalic arms has been attained by or through progressive gradations, typified by the organization of intermediate forms: the ancient Belemnites manifested the uncinated armature as perfectly as the most formidable of existing *Onychoteuthides*. Nor were true Calamaries, with uncinated arms, absent in those primeval seas, which were tenanted by living Belemnites, Ammonites, and other extinct forms of Cephalopoda. The existence of naked Cephalopods of the family *Teuthidæ* in the oolitic secondary formations, has been for some years demonstrated by the well-preserved and recognizable remains of the ink-bag, the gladius or horny pen, and the horny hooks developed from the acetabula of the cephalic arms.

These singular fossils have been elucidated by the minute and accurate descriptions of Dr. Buckland*, and have elicited some beautiful remarks from the same eloquent writer in his Bridgewater Treatise†. They have been noticed and described by Zeiten, by V. Meyer, and Count Munster, from the lias schale of Aalen and Boll, and from the Solenhofen slate. The impression of an entire Onychoteuthis with the double series of hooks belonging to the eight short arms, nearly in their natural position, is figured in the Sixth Livraison of M. D'Orbigny's 'Paléontologie Française,' 8vo, now in course of publication, under the name of *Celæno speciosa*, assigned to it by Count Munster. These hooks very closely resemble those of the *Belemnites Owenii*, but their base is rather less recurved, and they are more closely arranged: the fleshy part of the arms is not preserved; but they were evidently shorter in proportion to the mantle than in the Belemnite.

In conclusion, if we compare the Belemnite as now restored‡, not conjecturally, but by observation of phenomena, with the known existing forms of the Dibranchiate

* Proceedings of the Geological Society, 1829. † Vol. i. p. 303. ‡ Pl. VIII.

or higher order of Cephalopods, in which its right of place can no longer be disputed, we shall first recognize in the outwardly concave plates and margino-ventral siphon of the chambered shell of the Spirula, the analogue of the hydrostatic part of the shell or phragmocone of the Belemnite: next in reference to the entire shell we must admit, agreeably with the opinion of De Luc, Miller, De Blainville and Buckland, that the *Sepia* or common Cuttle Fish, most nearly resembles the Belemnite in the general structure and position of its complex calcareous plate. The nucleus or terminal spine of the sepium or cuttle bone corresponds with the terminal spathose guard of the Belemnite; the convex posterior broad plate of horny with friable calcareous matter is analogous to the capsule of the phragmocone; but its margins, instead of being approximated and soldered together, are free and lateral in position: the congeries of transverse plates, lodged in the concavity of the nucleus and of the foregoing semi-capsule of the cuttle-bone, answer to the chambered phragmocone of the Belemnite, but, instead of being perforated by one or many siphons, they are entire and connected with each other by a series of minute undulating lamellæ perpendicular to their plane.

The lateral fins of the Sepia are narrow, and extend, as is well known, from the apex of the mantle to near its base; while the fins of the Belemnite were relatively shorter and broader, and situated a little in advance of the middle of the body. In the relative size, shape, and position of the fins, the Belemnite must have most nearly resembled the species of the existing genera *Rossia* and *Sepiola*, but it differed in the more elongated and slender body.

The character of the formidable hooks, supported by the acetabula of the arms, is now exclusively manifested by the genus *Onychoteuthis*.

Thus the extinct Belemnite combined characters at present divided amongst four distinct genera of Dibranchiate Cephalopods, *Spirula*, *Sepia*, *Sepiola*, and *Onychoteuthis*. But, notwithstanding the uncinated character of the arms, the balance of its natural affinities seems to me still to preponderate in favour of its position as a transitional link between *Spirula* and *Sepia*: and the additional facts which we have now unexpectedly gained, while they show new and unsuspected radiations of affinity tending to complete the reticular interdependencies of the Cephalopods, do not disturb, but confirm the position of the Belemnite, in the linear series of the genera of that class which I proposed in 1836.

The Belemnite, with the advantage of its dart-shaped and well-balanced shell, must have enjoyed the power of swimming backwards and forwards by the action of its cephalic and pallial fins, with greater vigour and precision than the modern Decapod *Dibranchiata*. The position of the animal was, most probably, more habitually vertical than that of its recent congeners. Thus placed, the Belemnite, in quest of prey, would rise swiftly or stealthily to infix its claws in the belly of a supernatant fish, and then dart down, and drag its prey to the bottom and devour it. And we

cannot doubt, but that, like the uncinated Calamaries of the present seas, the ancient Belemnites and their associates, the Celænos, were, in their day, the most formidable and predaceous of Cephalopods.

We admire the skill of the Egyptian embalmers, which has enabled CUVIER* to test the influence of time in transmuting specific forms, by a comparison of the *Ibis* of the present century with one that died 3000 years ago. The researches of the chemist may afford an insight into those properties of the soil, in which the above described valuable and instructive specimens of Cephalopoda were entombed, that favoured the apparent conversion of their muscular tissue into adipocire, and its subsequent preservation to the present day. I can only describe this conservative matrix as a peculiarly fine and compact, but fissile, laminated variety of the Oxford clay: a formation at the base of the great middle oolitic system, more ancient than the Portland stone, the Wealden and the entire Cretaceous group. The Cephalopods in which we may now study the microscopic character of the muscular fibre, must therefore have existed at a period antecedent to the gradual deposition of these enormous masses of the secondary strata, which themselves preceded the formation of the entire tertiary series, and the overspreading unstratified masses, called diluvial. The attempt to conceive or calculate the period of time which must have elapsed since the Belemnites were thus embalmed, baffles and awes the imagination.

DESCRIPTION OF THE PLATES.

All the figures are of the same species of Belemnite (*Bel. Owenii*, PRATT), and of the natural size, except where otherwise indicated.

The following letters indicate the same parts in each figure.

a. The guard.
b. The alveolus or socket of the guard for lodging,—
c. The phragmocone; ζ, the sheath; θ, septum; ι, siphon.
d. Muscular tunic of the mantle; η, fold of the sheath.
e. The pallial fins.
f. The infundibulum.
g. The levatores infundibuli.
h. Decussating muscular fibres of the head.
i. The uncinated arms.
k. The tentacula.
l. The eyes (?).
m. The lining or muscular tunic of the stomach.
n. The ink-bag.

* Discours Préliminaire sur les Révolutions du Globe, Ossemens Fossiles, tom. i. p. 141.

PLATE II.

Fig. 1. Spathose guard and crushed phragmocone of a *Belemnites Owenii.*

Fig. 2. Apical extremity of the guard, showing the ventral groove α, and the form of the transverse section above the groove.

Fig. 3. A transverse section of the guard through the alveolus, showing one of the partitions of the phragmocone.

Fig. 4. The guard of an embryo Belemnite.

Fig. 5. The guard of a young Belemnite, in the condition of an *Actinocamax.*

Fig. 6. A detached and crushed phragmocone, showing the folds of the capsule at η.

Fig. 7. A detached and crushed phragmocone in its capsule, η, with one of the partitions, slipped forwards, θ.

Fig. 8. A detached partition from near the base of the phragmocone.

PLATE III.

The specimen of *Belemnites Owenii*, from the Oxford clay, from the collection of the Marquess of NORTHAMPTON, P.R.S., showing the phragmocone, muscular mantle, and portions of the fleshy arms, preserved in their natural relative positions.

PLATE IV.

Fig. 1. The specimen from the collection of S. P. PRATT, Esq., F.R.S., showing the phragmocone, part of the muscular mantle, lateral fins and funnel.

c. The apex of the crushed and disturbed phragmocone.

d. Portions of the transverse muscular tunic of the mantle.

e, e. The two lateral fins: that on the right side is entire.

f. The remains of the infundibulum.

g. The levator muscles of the infundibulum.

m. The striated horny plate ascribed to the gizzard.

n. The remains of the ink-bag.

Fig. 2. Section of an embalmed Calamary (*Celæno*, MUNSTER).

PLATE V.

The specimen from the collection of S. P. PRATT, Esq., F.R.S., showing the muscular mantle, head, and uncinated arms.

d. Portions of the transversely fibrous coat of the mantle, obscured in many parts by apparently the remains of the pigmental coat of the skin.

i. The uncinated arms.

l. The remains of the eyes.

m. The striated horny plate ascribed to the gizzard.

PLATE VI.

Fig. 1. The specimen from the collection of WILLIAM CUNNINGTON, Esq.

Fig. 2. A magnified view of one of the horny hooks.

Fig. 3. A magnified view of part of the head with the fibrous bodies supposed to belong to the eyes.

PLATE VII.

Highly magnified views of the spathose and muscular textures of the Belemnite.

Fig. 1. A portion of a transverse section of the fibrous guard.

γ. The lines indicating the prismatic fibres.

β. The lines indicating the layers of growth.

ε. The triangular specks produced by abrasion of the surface.

Fig. 2. Longitudinal section of the fibrous guard, across the prismatic fibres, δ.

Fig. 3. Primitive muscular fibres of the *Onychoteuthis Banksii*, showing transverse striæ, similarly magnified.

Fig. 4. Primitive muscular fibres of the *Belemnites Owenii* magnified 600 diameters, linear.

PLATE VIII.

Restoration of the Belemnite, according to the structures observed in the specimens preserved in the Oxford clay at Christian-Malford.

The same letters indicate the same parts as in the foregoing figures.

d'. The continuation of the mantle over the phragmocone and guard of the internal shell of the Belemnite.