V.—*Observations on Belemnites.*

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AN attentive examination of Belemnites has enabled me to ascertain their zoological characters, and to distinguish between the different species which have been discovered more precisely than has yet been done.

The result of this examination I have now the pleasure of laying before the Geological Society; but before I proceed to describe the characters of these fossils, it will be interesting to notice the various opinions which have at different times been entertained respecting them. We may indeed derive some useful hints from ancient names and traditions, as pointing out the countries in which particular fossils are found, and hence obtain some knowledge of the strata occurring in the places to which such traditions refer.

I. *Geological Position of Belemnites, and a Sketch of the Opinions that have been entertained respecting their Origin.*

The geological position of Belemnites is in the lias and in the strata above it, as high as the chalk inclusive. None have ever been found in beds older than the new red-sandstone on the one hand, nor on the other in any of the formations above the chalk. They also occur frequently detached and bouldered among gravel and alluvial soils, the compactness of their substance having preserved them from complete destruction. In the beds to which they belong they occur in association with the remains of marine animals, and are so frequently met with that it is evident they were by no means rare in the seas in which they lived.

The term Belemnite is derived from βελεμνον, a dart or arrow, which the fossil is supposed to resemble; and hence the English name *Arrowhead* and the German *Pfeilstein*.

The fanciful opinions which have at various times been entertained respecting the origin of fossil organic remains, and which are to be attributed to a

total ignorance of geology, have existed in a very remarkable degree in regard to Belemnites. These fossils appear to have been among the earliest noticed, and although in the various conjectures which have been formed respecting them we may trace a gradual progress towards the truth, their real nature has not as yet been developed. It could in fact be only by the use of those guides which the present state of knowledge of natural history has afforded, that we could successfully arrive at a solution of the question.

The ancients observed these fossils; and in Ovid's Metamorphoses it is stated that the urine of the Indian lynx became converted into stone before it reached the ground, and thus formed the Belemnites, which were therefore named Lapides Lyncis, Lyncurium, &c. Another denomination was Idæus Dactylus, probably from their having been found on Mount Ida, and from their resemblance in form to fingers, or perhaps from their having been first noticed by those celebrated metallurgists of antiquity, who obtained that title from their being ten in number.

It was for a long time a common belief that these stones were petrified fingers; and this opinion was entertained by the Northern nations, whose gloomy forests fostered a natural tendency to the mysterious, and who embellished the nomenclature of natural history with many terms referring to supernatural agency: hence the common names of this fossil in the North, *Devil's Fingers, Spectrorum Candela,* &c.

In later times the Belemnite was supposed to be produced by electricity, and was called Lapis fulminans, and Thunderbolt.

In the latter part of the 17th century all figured stones (as fossils were then called) were by many writers considered to have no relation to the organic bodies they resembled, but to be only *lusus naturæ,* concretions which had accidentally obtained those forms; and although some persons adopted a sounder opinion in regard to the common fossil shells, yet they supposed the Belemnite to be truly mineral, and either a stalactite or a crystal.

Others finding fragments of Belemnites in the sandy country of Prussia, where amber is also found, imagined them to be that substance in a petrified state.

When more accurate notions respecting fossils were adopted, and the Belemnite was observed to occur always in association with marine productions (such as shells and the bones of Saurian animals), it was supposed, on account of the conical cavity at its broader end, to be a tooth of some unknown animal, or a spine, like those of Echini. Other ideas, which appear to have been merely conjectural, existed, that they might have been Alcyonia, or even Holothuriæ.

At length the Belemnite was considered to be the remains of a testaceous animal, and a new series of theories and conjectures arose. The form and cavity then afforded grounds for referring it to the genus Dentalium.

The concave septa induced Von Tressau to consider it as a limpet.

Klein in his *Descriptiones Tubulorum Marinorum,* published at Dantzic in 1731, appears to be one of the first writers* who entertained clear notions of its nature. His generic description is as follows: "Tubulus marinus fossilis, materiæ at seleniticam accedentis; teres; transversim fractus concentricis striis, in longitudinem fissus canaliculo pervio semper in medio posito donatus; in basi nonnunquam fovens conum olim testaceum concameratum, instructum siphunculo."

Breynius†, Da Costa, and Brander‡ added but little to the observations of Klein.

Plott, in the Philosophical Transactions for 1764, considerably extends our knowledge of the structure of the Belemnite, though an ignorance of the true nature of the molluscæ inhabiting the chambered univalves has led him to maintain several erroneous opinions with regard to the exact mode of its formation. He observes that the concave septa in the superior conical shell were connected by a siphuncle, and suggests that the animal lived in its outer chamber: he also considers the shell as having sustained no change, and proves this from the vestiges of its laminar construction, which he compares to that of the oyster. Yet Plott does not agree with Dr. Hooke, that the siphuncle extends through all the chambers; and gives a rather unsatisfactory account of the manner in which the animal is, according to his hypothesis, to leave the aperture of its first chamber without separating from the siphuncle, and to assume a figure which may permit it to crawl on the bottom of the sea and to drag its shell with it. He states that the animal, both on its return and in its progress, clasps the whole guard by two flaps or sides of its mantle, as a snail does a small branch of a tree, and that in so doing it deposits by excretion the lamellæ which form the guard (in a manner very similar to that in which the Cypræa increases its shell). The sulcus, which may be observed traversing the surface of the Belemnite longitudinally, he considers as indicating the interval in which the two flaps of the mantle must have met in thus clasping the guard.

As the chambered portion of the Belemnite is so closely analogous to the shell of the Nautilus,—Walch, Parkinson, and Lamarck agree in the opinion that, like that shell, it was destined to aid the buoyancy of its inhabitant: but

* Rosinus perhaps at an earlier time had published ideas corresponding with those of Klein, but I have no opportunity of referring to his work.

† Dissertatio de Polythalamiis.

‡ Phil. Trans.

the great difficulty was, how so small an apparatus should move so heavy a spathose body as the protecting shell or guard. To overcome this, each of the authors created a theory, agreeing in the conclusion, that the guard was originally light and porous, and has obtained its present solidity by the process of petrifaction.

Walch conceives that the guard of the Belemnite was formed of two hollow shells, inclosing a viscous fluid; the chambered cone being inserted into this cavity, its siphuncle passing through the fluid and terminating at the point of the shell. On this view the fluid in question would have produced specific lightness, and might as he conceives have been converted into radiating spar, and thus furnished the present appearance.

Mr. Parkinson supposed that the guard as well as the chambered apparatus was intended to increase the animal buoyancy. Hence, from a resemblance of the guard to some supposed echinital spines in the chalk, he refers to the internal organization of echinital spines; and finding this to be porous or cork-like, he conceives the guard to have been originally of a similar consistency, but now altered by the infiltration of calcareous spar. He further thinks, with reference to the tube observed by Walch as existing in the Belemnitic guard, that it might have been a continuation of the siphuncle; and this, communicating with the cellular substance of the guard, might by the admission of air or water have served to regulate the buoyancy thus acquired.

Lamarck conceives that the Belemnite was an internal shell once inclosed within the body of the animal, similar to the bone of the Sepia, and consequently like that bone, of a spongy or cellular form.

II. *Generic character.*

Genus. *Belemnites.* A cephalopodous? molluscous animal provided with a fibrous spathose conical shell, divided by transverse concave septa into separate cells or chambers connected by a siphuncle; and inserted into a laminar, solid, fibrous, spathose, subconical or fusiform body extending beyond it, and forming a protecting guard or sheath.

III. *Observations.*

I have already observed that the Belemnites are now admitted to have inhabited the sea; but as we are not acquainted with any living animals possessed of a similar structure, we must necessarily form our ideas respecting the animal of the Belemnite from the hints which its shell is capable of furnishing, by the muscular impressions it exhibits, and by its analogy to other testacea.

The conical chambered shell is easily separated by decomposition from its protecting guard, which being of a solid laminar spathose substance is very

durable, while the fragile texture of the chambered portion has rendered it liable to be destroyed by the least violence; and consequently this part has been preserved only when its chambers were filled with mineral matter; and even then a subsequent decomposition of the transverse septa has frequently separated the series of casts formed within the chambers.

The chambered structure of the conical shell of the Belemnite, and its siphuncle, exhibit a striking analogy with the Orthoceratite, the Nautilus, and the Ammonite. It differs, however, essentially from the Orthoceratite in the circumstance that all parts of its shell present on fracture a laminar fibrous spathose substance; in its being provided at its posterior end with a more or less elongated and encompassing guard or sheath; and in the siphuncle of the chambered cone being situated near the margin. This last character, combined with the fibrous and spathose texture of the shell, will at all times, in my opinion, afford a discriminating character between the chambered cone of a Belemnite (even when occurring separated from its guard) and the Orthoceratite.

From this analogy of the Belemnite to the Nautilus in the chambered parts of the shell, it appeared probable that, like the latter, it could be made buoyant at the will of the animal. But as my examination of the guard had led me to the conclusion that this part had been at its first formation solid and spathose as it is at present, a difficulty presented itself, as, although the form and weight of the guard would tend to preserve the animal in an upright position, yet this weight would more than counterbalance the buoyancy which could be obtained by chambered portions no greater than those found in the specimens which are commonly met with. To ascertain the size of the chamber which would be requisite to compensate for the weight of the guard, I made the following experiment.

I fastened with gum a piece of oiled paper of a conical form in the cavity from which the chambered part had fallen out of a large Belemnite; and putting into this cone some cotton, to prevent the paper from collapsing by the pressure of the water, I found that the apparatus floated with a paper of no larger size than from some known fine specimens we may fairly conclude the outer chamber to have attained.

Thus far successful, I now resorted to a particular examination of the belemnitic shell, to acquire, from its laminar construction and muscular impressions, facts to ascertain how far they might confirm or confute my theory,—that it had sustained no change by petrifaction, but was from its first origin composed of fibrous spar.

IV. *Particular Remarks on the internal chambered Cone of the Belemnite.*

It appears that the part of the animal's body which was once contained in the outer chamber secreted a thin layer of a spathose fibrous texture, and that a thin coat resembling nacre but not iridescent, covered the fibrous spathose layer externally and internally, and cemented the whole strongly together. It is evident that the external nacreous investment of this first lamina forming the chambered cone, could not be formed by that portion of the animal which was within the cone, but was secreted by parts encompassing it. The exterior surface of the cone is, however, less smooth than the interior, and offers thereby an admirable contrivance for its adhesion to the sides of the guard; proving also, clearly, that it does not result from the same portions of the animal which form the guard, and that this was formed subsequently.

As the portion of the animal within the cone increased in size, so it enlarged its encompassing shell at the upper margin, at the same time forming a transverse concave thin lamina at a short distance from the bottom of its shell, and carrying its sides for some height upwards, thereby affixing the lamina and strengthening the sides of the conical shell. Thus an inner chamber was formed, from which the animal was completely excluded, and with which it only communicated by its siphuncle extending on one side into it. The siphuncle appears to have been encompassed by a spathose lamina connected above and below with the transverse one, and affixing laterally to the conical shell.

Each transverse septum is composed of three or four spathose laminæ, separated from each other by the investing nacreous layers just described. The sides of the upper laminæ are carried up to nearly the same point where those of the first formed laminæ terminate: each, however, successively becomes a little shorter, and thereby forms a circular rim on which the transverse lamina forming the next chamber rests. Hence there results a series of concave cups, whose edges take a conical direction and whose sides adhere to a thin encompassing conical shell, thereby strengthening the latter, and forming an assemblage of chambers, through the whole of which the siphuncle extends.

These laminæ exhibit throughout a fibrous and spathose structure, the direction of the fibres always forming radii to the curvature of the part. They are covered above and below with a nacreous investment, which being opaque or differing in colour, exhibits when the shell is dissolved in diluted acid clear traces of the animal matter forming fine pellicles. The preservation of these pellicles appears to me to afford an argument in confirmation of my views,—that the intermediate layers of fibrous spar belonged to the original texture of the shell, and are not the result of subsequent infiltration; otherwise it appears

probable that in the progress of crystallization these pellicles would have been disarranged and obliterated.

Several circumstances induce me to believe that the last or outer chamber of the conical shell could at no time have possessed any great depth; for the thin parietes of the conical shell could have acquired but little additional strength from the extension of the edges of the last septum; and had they therefore projected far beyond it, so frail a fabric would have been liable to be squeezed in by the lateral pressure of the water. Indeed, a section of a perfect specimen imbedded in its matrix, in my possession, in which the termination of the parietes of the upper chamber is distinctly to be traced running to a sharp edge, confirms this fact,—that the outer chamber was like the rest, very shallow.

The chambered shell appears also from this and several other specimens to have considerably extended above and beyond the upper extremity of the guard. Hence we may conclude that the casts of large chambers often found separate, do not indicate that the guard was of equal size. From the shell being frequently traversed by numerous septa, it acquired a considerable degree of strength and a power of resistance to the pressure of the surrounding water, whilst it aided the locomotive power of the animal by its buoyancy.

V. *Particular Remarks on the Structure of the external Guard or Sheath of the Belemnite.*

The form of the guard or sheath varies in different species. In some it is fusiform, in others conical; in some slightly elongated, in others it is of considerable length; in some it has a round, in others an elliptical circumference. Its termination is either acutely pointed, or conical; either compressed, or mamillated; and sometimes the apex is slightly aduncated. Some species have one, and others two or three longitudinal grooves. The surface of some is smooth, in others it is slightly granulated; and on some species we may trace impressions which evidently betray marks of muscles which have clasped or encompassed this part of the Belemnite, and show the impressions of branching vessels.

Some species are semitransparent, others are opaque: in the former we may observe that the guard is formed of two or three nearly equal longitudinal portions, and along the line marking their adhesion the Belemnite easily separates by a slight blow with a hammer, or by being heated and afterwards moistened with cold water. By the same means a similar organization may be discovered in the opaque ones. The edges of these longitudinal portions are irregularly waved, and adhere closely together.

A longitudinal or transverse fracture of the guard, shows that it is formed of several concentrically superposed laminæ perfectly corresponding with those in the chambered cone; each similarly formed of an arrangement of spathose fibrous crystals forming radii to its curvature, and also covered and cemented together by a very thin nacreous investment, which by being of a less pellucid appearance affords a mark which enables us to trace the thickness of each lamina.

The circumstance above stated with regard to the division of the belemnitic guard into two or three longitudinal portions, may perhaps authorise the conjecture, that its laminæ were secreted in these separate parts by two or three distinct longitudinal portions or flaps of the animal, laterally touching each other, with irregular edges from whence resulted the irregular suture.

As the animal, by its situation in the first chamber of the conical multilocular shell, cannot form the guard in any other manner than by apposition of its laminæ externally, it is rendered thereby certain that this must have been effected by portions of the animal protruding over the edge of the upper chamber, and encompassing the whole of the exterior both of the shell and the guard.

I have before expressed my opinion, that the laminæ of radiating spar interposed between the nacreous layers of the chambered portion, belong to the original organization of the shell, and had not been introduced by subsequent infiltration; and I must here repeat the same opinion with regard to the similar laminæ of the guard. If we consider the system of nacreous layers alone, abstractedly from the intervening sparry matter, the guard would exhibit a texture greatly resembling the bone of the cuttle-fish (*Sepia officinalis* Linn.); namely, a series of concentric calcareous layers, separated by very narrow intervals, and held together by transverse fibres: and such in fact is the appearance it often presents when the sparry matter is removed by partial decomposition. But I cannot persuade myself, that if the spathose substance had been subsequently introduced by infiltration into the cavernous intervals of such a structure, it would have there shot into radiating crystals, without obliterating and destroying all traces of the frail intervening plates. I think that I am able to show that such an obliteration of the internal structure has taken place (with the exception of a few cases) in the instance of echinital and crinoidal remains, which by their conversion into an uniform and peculiar modification of calcareous spar, would afford a case analogous to that of the Belemnite, should we consider the sparry state as superinduced in it.

I may mention, in support of the opinion here expressed, that the large tubular shell found in the Eastern seas, and called by Lamarck *Septaria are-*

naria, is composed of radiating crystals of carbonate of lime. This instance is important in illustration of my theory, as showing the actual existence of such a structure in the shell of a living animal.

VI. *Effects of Decomposition on the Shell of the Belemnite.*

In many shells, such as Nautili, Ammonites, and Trochi, the common calcareous outer part yields more easily to decomposition than the iridescent nacreous internal coating*. We see instances of this in the thin iridescent flattened scales of Ammonites found at Watchet, which are the remains of partly dissolved shells.

In the Belemnite, however, it appears that the nacreous portion yielded to decomposition more readily than the spathose parts.

The proofs of this are to be found in the frequent separation of the guard from the chambered cone. These parts were originally connected by nacreous matter, and it is the decay of this matter which has caused them to separate. The further process of decomposition acting on this cavity, produces a groove along the line between the two portions of the guard.

The central canal, which on breaking the Belemnite is sometimes found to traverse the axis of the guard, and which has been considered by some writers as a channel for nerves or vessels, and by others as a continuation of the siphuncle, is also to be attributed to decomposition.

There is no connexion whatever between this channel and the chambered portion, which is completely invested and surrounded by the inclosing shell. The manner of its formation appears to me to be, that the nacreous layer which is deposited between each of the spathose ones, is continued at the apex of the guard into a prolonged point, so as to reach the succeeding nacreous layer; and this substance having decayed while the spathose part remained unaltered, a continuous channel has been formed.

Decomposition also shows itself sometimes in removing the calcareous matter, cementing together the longitudinal portions of the guard, and sometimes we find that particular layers of the calcareous matter are attacked (perhaps from some peculiarity in their composition making them more liable to decay): and thus a separation takes place between the outer portion of the series of layers and those within the decayed layer. The inner portion is what at an earlier stage of growth was the whole of the belemnitic guard. The outer portion has,

* This nacre may be better calculated to resist decay, on account of its containing (according to Mr. Hatchett's experiments) 24 per cent of animal membrane, possessing properties similar to coagulated albumen. We have no means of ascertaining what proportion of such substance existed in the nacre of the Belemnite.

from such a decay, an accidental cavity, which may be distinguished from the cavity of the chambered part by its difference in form; the accidental cavity being of the form of a more elongated cone, and having also frequently a projecting point arising from matter accidentally indurated in the central canal, above noticed, as having been mistaken for the continuation of the siphuncle.

In some fragments of Belemnites, two conical cavities have been observed; one of these is undoubtedly the cavity of the chambered shell, the other has arisen from the accidental falling out of a portion of the guard.

On immersing the guard in dilute acid, we discover that animal matter intervenes in small quantity between the fibrous crystals.

If, as I have supposed, the guard was originally of a crystalline structure, it would certainly present great obstacles to decomposition. This is indeed proved by the shells of the genus Pinna; the only ones, I believe, which, having a texture resembling that of the Belemnites, are found both in a recent and a fossil state. The fossil Pinnæ found in the lower beds of the London clay at Bognor, and in the Paris beds, retain distinctly the same structure as the recent ones.

The fibrous shell so frequent in the oolite (supposed to be an oyster and described as Ostrea Trichites, but evidently from its peculiar organization belonging to a distinct genus) and the Inoceramus of the chalk, presents a fibrous and more or less crystalline texture, which in these cases no one has ever doubted to have belonged to them in their original state.

I have seen, in the collection of Richard Bright, Esq., many specimens where Belemnites had been imbedded in flint, and have been dissolved out; and in the hollows which they had occupied, are remaining siliceous casts of those spherical bodies with connecting fibres which the Rev. W. D. Conybeare has described in the 3rd volume of the Geological Transactions as resulting from the infiltration of silex into cavities formed by some boring animal. Mr. Allan has also figured these bodies in Belemnites in the Edinburgh Transactions. In Mr. Bright's specimens, some small portions of the radiating calcareous spar of the guard of the Belemnite are remaining among the connecting siliceous threads.

Von Tressau observes, as a proof of the indestructibility of the Belemnites, that those found in iron mines along with Ammonites and Nautili, have sustained no change, whilst the latter are converted into ochre.

The Belemnite in fact rarely occurs otherwise than with such a texture as may present on fracture a fibrous spathose organization; and where this has been penetrated by silex or other mineral substances, it has always, and but with only one exception, destroyed its peculiar formation.

In the Lyas and Lyas-clay, pyrites frequently enters the chambered cone, which on account of its more fragile construction it is able to attack, whilst the guard resists its operation. Sometimes we meet with the shell of the chambered cone in a semi-decomposed state, involved in pyrites, and flattened as far as it projected beyond the guard, or as far as its latest formed and adhering laminæ were unable to resist the pressure of incumbent matter. In other instances we obtain a beautiful conical pyritic cast showing marks of the rim of the concave septa (the outer shell of the cone being destroyed), and the situation of the siphuncle in a series of indentures, which from a hasty and mistaken analogy have been once considered as the spiracula of the Belemnite.

I possess a Belemnite in chert from Dantzic, which is converted into chalcedony, and where the fibrous structure of the shell is entirely destroyed. The chalcedony has assumed its own mineral figure, and has a mamillated surface in the cavity once occupied by the chambered cone. A transverse fracture shows a few concentric markings common to chalcedonic nodules.

Miss Benett of Norton House is in possession of a few specimens of Belemnites minimus, from near Warminster, (much resembling Parkinson's representation in the 3rd volume of Org. Rem. Pl. IV. fig. 14.) which have experienced the changes so often exhibited by the fossils imbedded in green-sand, and which have gradually silicified. It is owing to the kindness of that lady that I have been able to examine these Belemnites carefully. They exhibit in their present state externally a few thin conical lamellæ superimposed on each other, and adhering by transverse fibres somewhat analogous to the structure of the common cuttle-fish, and are in many instances hollow in the centre. My explanation of this structure is, that these now siliceous lamellæ have replaced the nacreous layers; and that the intervening fibrous crystalline substance, as well as the lamellæ forming once the centre of the guard, have disappeared by decomposition. Belemnites of this kind are very rare; and it is interesting that some of these show the same irregular cavities as I noticed in a calcareous specimen in Mr. Greenough's possession, similar to the one figured in Knorr (Vol. III. Supp. iv. f. fig. 8.).

Accident furnished another clue to the illustration of the cavities in the specimens referred to, ascribed to the mere dropping out of certain portions of the laminæ by decomposition. I observed on the surface of a few specimens of Belemnites from the oolite at Dundry, some circular markings, occasionally one within the other, having an irregular floriform petal-shaped and sometimes subvermicular circumference, similar to those represented in Knorr (Vol. II. part ii. Pl. I.* fig. 5.); which Walch there considers as marks occa-

sioned by worms or decomposition. On exposing one of these Belemnites to the action of nitric acid, to detect the animal gluten, I found to my surprise that these markings were a siliceous insinuation, sometimes extending in most delicate fibres between the crystals forming the laminæ. These circular figures on calcareous and siliceous shells are by no means uncommon; and I was pleased to detect them also in the silicized Belemnites in Miss Benett's collection.

VII. *Chemical Analysis of the Belemnite.*

Acton found the species of Belemnite he analysed to contain

45·55	carbonic acid
53·95	lime
40	oxide of manganese and iron
10	water and loss
100	

No alumine could be detected by succinate of ammonia. I have no doubt that the different species of Belemnites would furnish different analyses, but am at present prevented from going into these details.

On immersing the Belemnite in diluted nitric acid, I detected the interlacing animal matter exhibiting appearances similar to those in nacreous shells. A stronger acid tore the fibres asunder, coloured the solution yellow, and evolved a very pleasant smell resembling that of Cerambix moschatus. On scraping or burning the Belemnite, it evolves a smell by no means unpleasant. On exposure to fire, the crystalline laminæ lose their water of crystallization, and assume an opaque, white, fibrous, submargaritaceous appearance.

In those early periods of science in which almost every substance of singular form was supposed to possess occult medical qualities, the Belemnite was considered as a protector against several complaints. Dr. Woodward informs us, that in Gloucestershire they use it pulverized in watery affections of the eyes of the horse, by blowing it into them. It is also used internally in nephritic cases. In Prussia they use it pulverized in the dressing of wounds.

VIII. *Conjectures on the Form of the Inhabitant of the Belemnite.*

There can be no room to hesitate in agreeing with Cuvier and Lamarck, that the Belemnite belonged to the cephalopodous division of Mollusca. The identity of structure in the chambered portion with the other genera of multilocular shells is alone sufficient to prove this; and we shall presently find additional confirmation of the same fact. The cephalopodous division of Mollusca consists only of two subdivisions, nearly allied to each other in the general cir-

cumstances of their structure; namely, the Nautilacea and Sepiacea. The former are provided with multilocular shells, probably intended as an apparatus to regulate the animal's buoyancy: but of this subdivision, only one genus, the Spirula, has been examined with anatomical precision, and it therefore remains involved in much obscurity. The second subdivision, the Sepiacea, have no shell; but in lieu of it, a complex laminated calcareous mass (somewhat improperly termed bone, and well known in commerce as cuttle-fish bone,) exists in the genus Sepia, and a horny plate in the genus Loligo. The former may very possibly, like the multilocular shells, assist, by its porous and cellular structure, to render the animal more buoyant; but the latter can scarcely answer any other purpose than giving a support to the contiguous muscles. The animal of the Belemnite probably formed an intermediate class of the order, uniting the internal multilocular shell of the Spirula with the laminated calcareous mass of the Sepia, to which the belemnitic guard appears to correspond, as it is formed in a manner exactly similar; namely, by the apposition of successive laminæ, of a concentric curvature, upon each other, in successive strata: the only difference being, that in the cuttle-fish those spaces are not closed and the edges of the laminæ do not meet in a circle; whereas in the Belemnite, the parts secreting the shell, bending and closing round so as to embrace a conical surface, made the laminæ assume the same direction and curvature. From the interstices between the laminæ not having been empty, but, as I have supposed, filled with spar at the period when the animal formed the guard, I conjecture that the buoyancy of the animal must have been provided for by the chambered shell, and that the guard acted as a counterpoise to it.

With these views, I believe the inhabitant of the Belemnite to have been a Sepia-like animal, having a body of an abbreviated form partly inserted into the first chamber or aperture of the chambered cone, and connected to it by a duct extending from it to the end of the siphuncle. I further conceive, that a powerful circular muscle inclosed the chambered cone as far as the place where the laminæ of the guard encompass it; and that another muscle extended on one side over the guard for its whole length, having laterally adhering to it on each side, a muscle provided with a secreting surface and capable of encompassing the guard. This form of the animal would admit the formation of the shell of the Belemnite, and correspond with the details its organization presents.

When the animal increased in size, it formed a new septum in front of the chambered cone, adding at the same time a new rim to the cone. Hereby its shell acquired a new chamber and a greater degree of buoyancy, to counteract

which, a new spathose and nacreous lamina was secreted over the guard; an effect not capable of being produced, had the guard originally possessed a laminar cavernous organization.

I believe it will be proved by further researches, that all chambered shells are inclosed in, or capable of being covered and encompassed by, the animal; for without such a contrivance, that nice degree of buoyancy which they are intended to furnish to the animal would be destroyed by the adhesion of parasitic testacea, from which a perfect protection is thus obtained. From the size of the animal and the smallness of the outer chamber, it is clear that the inhabitant of the Belemnite could never entirely withdraw within the shell; and it appears probable that the guard, independent of its use in preserving a well-adjusted buoyancy, was also intended to furnish to the muscles an abutment and support on which they could adhere, and from which, like a fulcrum, they could receive additional strength.

The surface of the two lateral muscles which encompassed or clasped the guard, had each a distinct power of secretion, although they formed their laminæ at the same time. This accounts for the sutures which separate the guard into two longitudinal portions. These muscles, in some specimens appear not to have increased in proportion to the laminæ they encompassed, and therefore, when the guard greatly enlarged, to have been unable to secrete other laminæ completely surrounding the former. Hence arises sometimes a groove on one side, frequently in old specimens displaying the shortening of the laminæ as they accumulated and as the edges of the muscles were withdrawn.

In some species the muscles appear to fold together near the apex, and form two or three grooves in this part; while in others they lap over the apex and form a mamillar termination. In very perfect specimens we may observe in some species a longitudinal slit in the guard where it adheres to the chambered cone, evidently also arising from the causes cited before. On the guard of such specimens we may distinctly trace impressions of the branching blood-vessels in each of the two longitudinal muscles; which furnishes, in my opinion, *a most satisfactory evidence that the guard was really enveloped by them in the manner in which I have stated.*

Description of the Species.

In endeavouring to fix specific characters to the various Belemnites that have fallen under my observation, and which I have considered as distinct species, I ought to state that they are chiefly derived from that part which I have called

the guard. I must however acknowledge the insufficiency of this part to yield distinctions which may secure us from all error. It is obvious how much a form is liable to be changed where it results from the continual superpositions of fresh laminæ, which if not regularly and conformably secreted, produce not unfrequently considerable deformity and deviations.

Sp. 1. Belemnites abbreviatus (nobis). Pl. VII. fig. 9, 10.

Sp. Ch. Guard short in proportion to the length of the chambered cone, tapering to a conical and very slightly curved point, compressed on two sides.

Syn. and Ref. Parkinson's Org. Rem. vol. iii. Pl. VIII. fig. 8 & 15.

Locality. Weymouth, Dundry.

Stratum. Inferior oolite.

This species grows large, the chambered cone has generally a lateral position, in consequence of the accumulation of laminæ being on one side more than on the other; hence its apex forms frequently a slight curve. The guard is also thicker on one side than the other; hence somewhat suboval, and not unfrequently finely striated longitudinally.

Sp. 2. Belemnites aduncatus (nobis). Pl. VIII. fig. 6, 7, 8.

Sp. Ch. Guard very smooth yet sometimes finely striated, cylindric, terminating in an aduncated apex marked with four or five ridges, the sulci between which are sometimes slightly tuberculated.

Locality. Weymouth, Lyme.

Stratum. Lyas and lyas clay.

This species is considerably more slender than the former, but otherwise resembles it.

Sp. 3. Belemnites sulcatus (nobis). Pl. VIII. fig. 3, 4, 5.

Sp. Ch. Guard subcylindrical, elongated, having a longitudinal sulcus, and terminating in an acute apex.

Syn. and Ref. Plott's Hist. of Oxford, Tab. III. fig. 6.

Locality. Dundry, near Oxford.

Stratum. Inferior oolite.

This species has sometimes a considerable thickness, when the sulcus is very distinctly marked, evidently occasioned by the upper laminæ not completely surrounding the guard.

Sp. 4. Belemnites elongatus (nobis). Pl. VII. fig. 6, 7, 8.

Sp. Ch. Guard slender, tapering to a conical point.

Syn. and Ref. Platt in Phil. Trans. vol. liv. for 1764, and in the Abridgment of ditto, vol. xii. Pl. III. fig. 8.

Locality. Lyme in Dorsetshire.

Stratum. Lyas and lyas-clay.

This is a slender species of a dark brown colour, generally showing very distinctly the organization of its guard in the superposition of its laminæ.

Sp. 5. Belemnites longissimus (nobis). Pl. VIII. fig. 1, 2.

Sp. Ch. Guard very thin, long, smooth and terminating in a conic point.

Locality. Lyme in Dorsetshire.

Stratum. Lyas and lyas-clay.

This species is very remarkable on account of its slender form, generally of a yellow brown colour and more than usually opaque.

Sp. 6. Belemnites acutus. Pl. VIII. fig. 9.

Sp. Ch. Guard conical, terminating in an acute point.

Syn. and Ref. Luid. Tab. XXV. fig. 1683?

Sp. 7. Belemnites tripartitus. Pl. VIII. fig. 10, 11, 12, 13.

Sp. Ch. The guard is formed of three longitudinal portions, showing near the apex three distinct longitudinal ridges.

Syn. and Ref. Von Schlotheim Petrefactenkunde, vol. i.

Sp. 8. Belemnites ellipticus (nobis). Pl. VIII. fig. 14, 15, 16, 17.

Sp. Ch. Guard opaque, grayish brown, much elongated, elliptical, terminating in a mucronated point.

Syn. and Ref. Knorr, Monum. vol. iii. sup. IV. fig. 3 & 4.
Klein, Tub. Mar. Tab. IX. fig. 3 & 4.

Locality. Iron mines at Fuerslenberg (Knorr), Dundry.

Stratum. Inferior oolite.

It is a very large and long species, almost opaque and of a pale yellow brown colour. The guard in an early state of growth is generally round, as may be seen in transverse sections, but becomes subsequently, by an apposition of laminæ of irregular thickness, of an elliptical form.

Var. *α.* The guard less elliptical, terminating in a conical point.

Locality. Dundry.

Stratum. Inferior oolite.

Probably only young specimens of the former.

Sp. 9. Belemnites electrinus (nobis). Pl. VIII. fig. 18, 19, 20, 21.

Sp. Ch. Guard amber-colour, nearly transparent, cylindrical, lower end conical, with a mamillated point. In perfect specimens, where the guard adheres to the chambered cone, a longitudinal groove in the centre. On the surface generally traces of the impression occasioned by two longitudinal branching blood-vessels.

Syn. and Ref. Park. Org. Rem. vol. iii. Pl. VIII. fig. 12; and a bouldered fragment, fig. 10.
Faujas St. Fond, Hist. Nat. de la Mont. de St. Pierre, Pl. XXXII. fig. 3.
Mantell's Geol. of Sussex, Tab. XVI. f. 1.

Locality. Salisbury, Isle of Moen, and Rügen, Berwick near Hindon, Brighton, Lewes. Bouldered fragments in the sands of the north of Prussia.

Strata. In the Chalk formations. The bouldered fragments in the sands of Prussia are probably derived from displaced beds of chalk formerly in connexion with the Isle of Moen and Rügen.

The mamillated point of this species being formed of more nacreous matter than the rest of the guard, becoming as the guard increases in length its axis, produces on decomposition the central canal described before.

Sp. 10. Belemnites fusiformis (nobis). Pl. VIII. fig. 22. Pl. IX. fig. 5, 7.

Sp. Ch. Guard contracted in diameter below the point of the chambered cone, swelling out again and terminating in an acute point. A deep sulcus extends for nearly the whole length of the enlarged portion of the guard.

Syn. and Ref. Luid, Tab. XXV. fig. 1705.
Park. Org. Rem. vol. iii. Pl. VIII. fig. 13.
Hibolithus hastatus. De Montf. vol. i. p. 587.
Porodragus restitutus. De Montf. vol. i. p. 591.

Locality. Stonesfield, the environs of Gap.

Stratum. Stonefield slate.

The laminæ forming the shell of this species are nearly opaque, and of a dark gray brown colour. The porous appearance of the guard which De Montford has described as a character of the genus Porodragus, appears to be the result of decomposition.

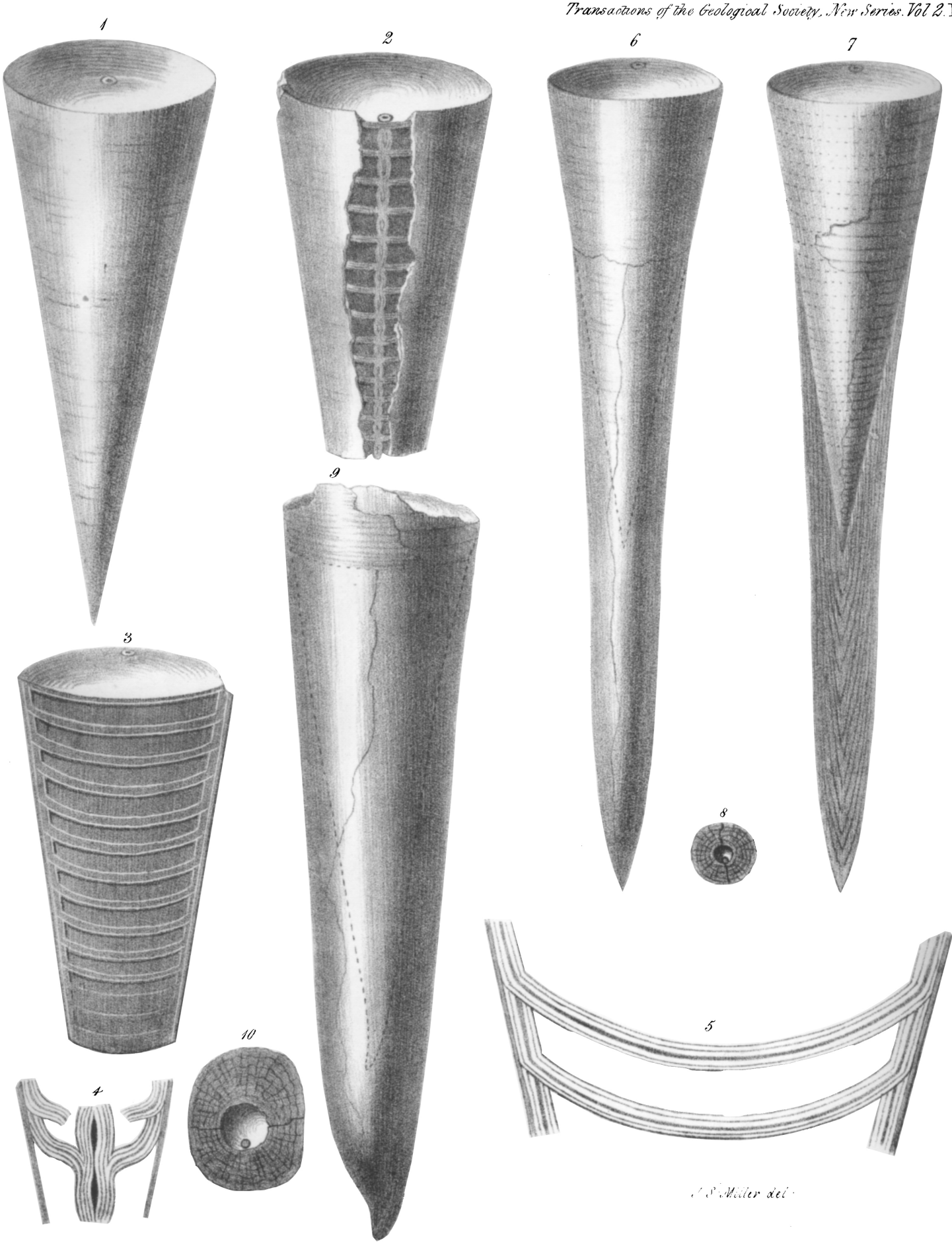
Sp. 11. Belemnites minimus. Pl. IX. fig. 6.

Sp. Ch. Guard subfusiform, corneous, semitransparent, showing two ridges, point conical, convex, submamillated.

Syn. and Ref. Belemnites minimus. List. Hist. Ang., p. 228. fig. 32.
Belemnites Listeri. Mantell's Geol. of Sussex.

Locality. Folkstone, Ringmer, Sussex, Surry, Kent, Cambridgeshire, Stutgard ? in Prussia.

Of this species I have not yet seen the chambered cone. The guard shows frequently the central canal formed by decomposition, as also impressions of the two longitudinal vessels. The nacreous laminæ have sometimes a subiridescent colour.



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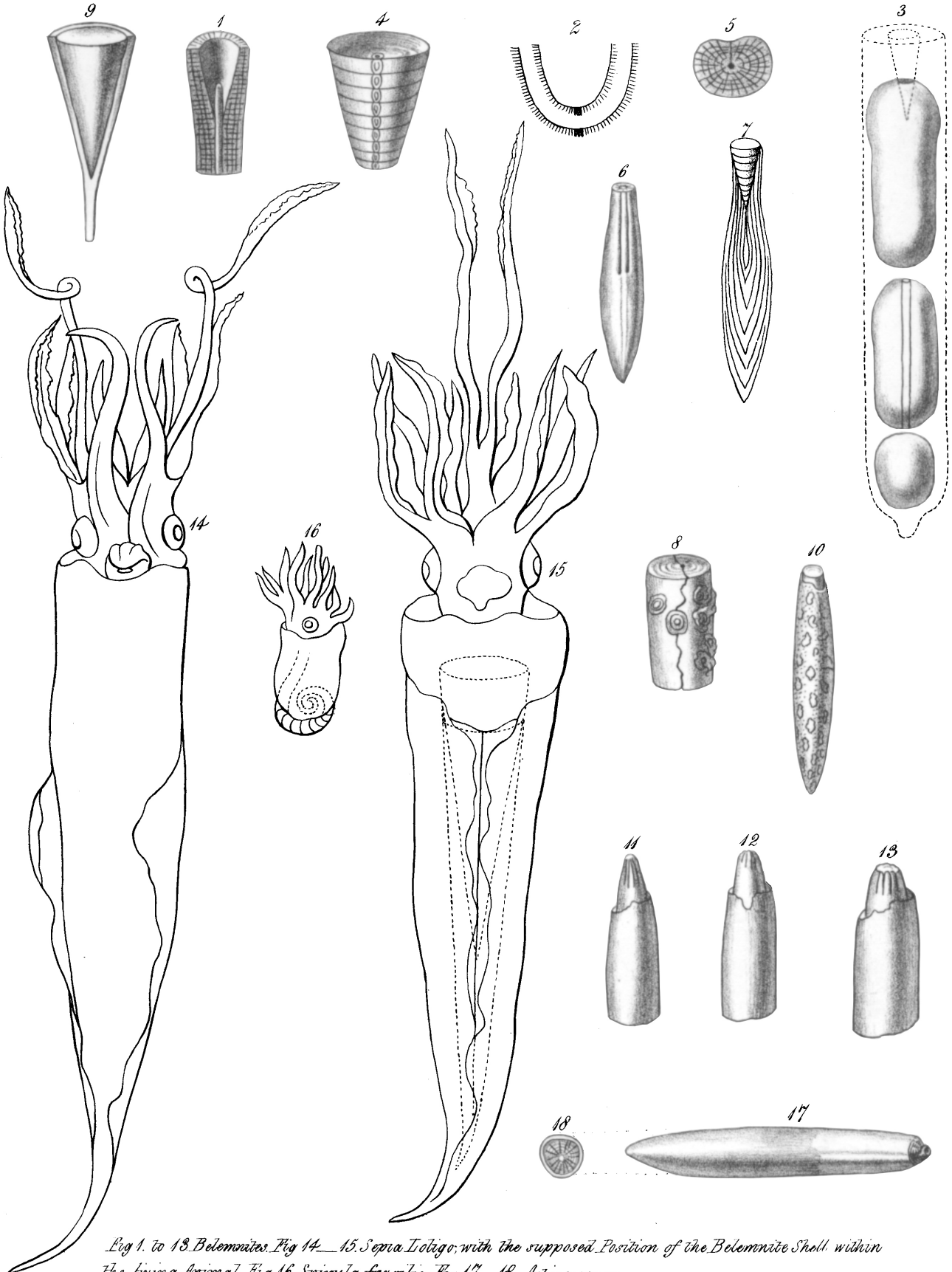

Fig 1. to 13 Belemnites. Fig 14__15. Sepia Loligo; with the supposed Position of the Belemnite Shell within the living Animal. Fig 16. Spirula fragilis. Fig 17__18. Actinocamax.

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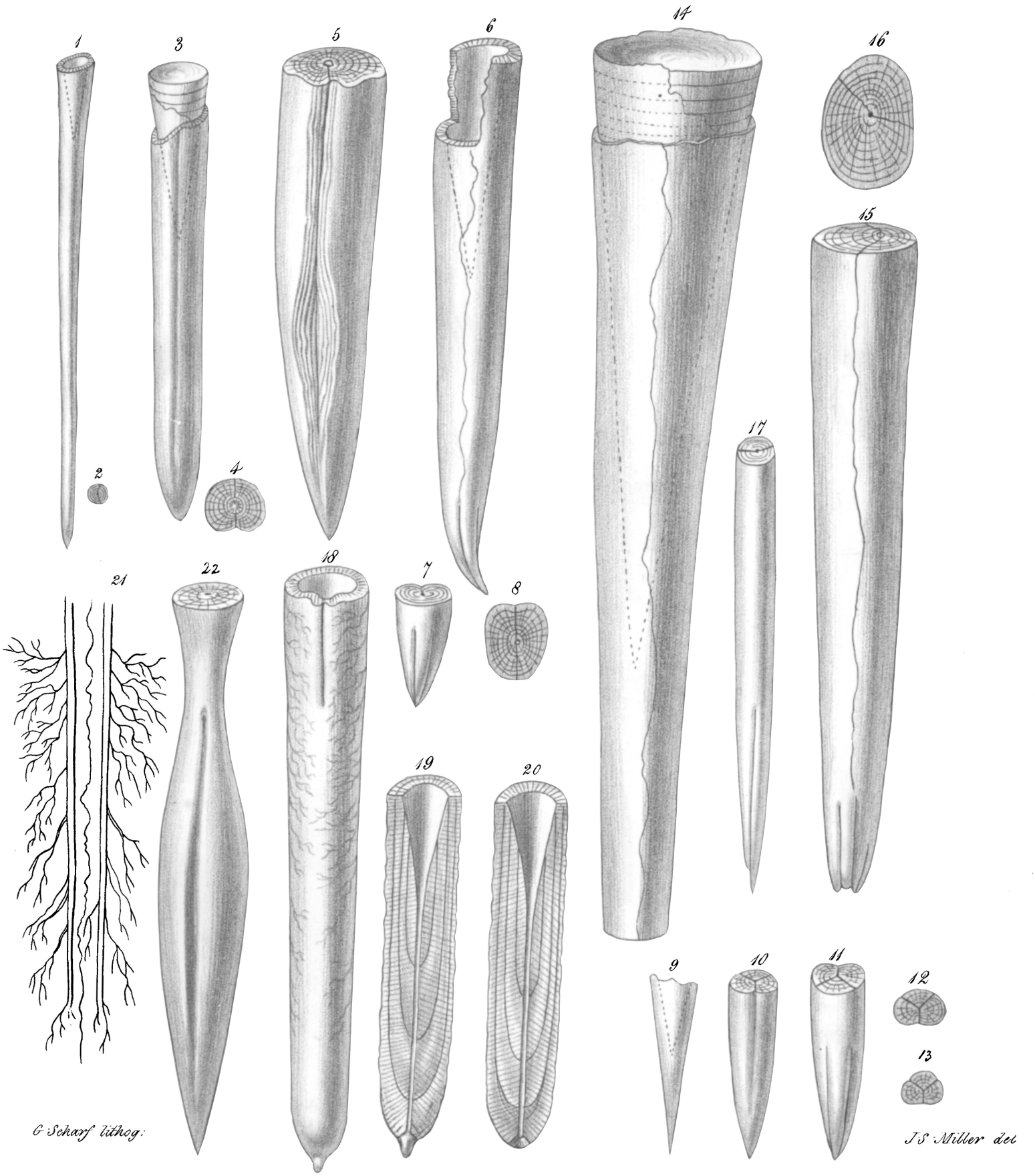
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