Annals and Magazine of Natural History

Series 2

ISSN: 0374-5481 (Print) (Online) Journal homepage: <http://www.tandfonline.com/loi/tnah08>

I.—On the nervous system of *Ommastrephes todarus*

Albany Hancock

To cite this article: Albany Hancock (1852) I.—On the nervous system of *Ommastrephes todarus*, *Annals and Magazine of Natural History*, 10:55, 1-14, DOI: [10.1080/03745485609495618](https://doi.org/10.1080/03745485609495618)

To link to this article: <http://dx.doi.org/10.1080/03745485609495618>

Published online: 17 Dec 2009.

Submit your article to this journal [↗](#)

View related articles [↗](#)

Citing articles: 3 View citing articles [↗](#)

THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[SECOND SERIES.]

"..... per litora spargite muscum,
 Naiades, et circum vitreos considite fontes : •
 Pollice virgineo tencros hic carpite flores :
 Floribus et pictum, divæ, replete canistrum.
 At vos, o Nymphæ Craterides, ite sub undas ;
 Ite, recurvato variata corallia trunco
 Vellite muscosis e rupibus, et mihi conchas
 Ferte, Deæ pelagi, et pingui conchyliis succo."
N. Parthenii Giannettasii Ecl. 1.

No. 55. JULY 1852.

I.—*On the Nervous System of Ommastrephes todarus.*
 By ALBANY HANCOCK.

[With two Plates.]

THE Cephalopods are undoubtedly the most highly organized of all the *Mollusca* ; their external organs, however, are of so abnormal a character, that any attempt to trace their homologies in the lower groups of that subkingdom would at first sight appear almost hopeless. Notwithstanding, numerous efforts have been made with that view by able naturalists ; but apparently without much success, for our knowledge on this subject still remains in a most unsatisfactory state.

For the purpose of elucidating this difficult problem, I have recently dissected with much care the nervous system of *Ommastrephes todarus*—the *Loligo sagittata* of English authors, and now propose to give a detailed description of it, refraining at present from any attempt to arrive at just conclusions respecting the nature and signification of the organs of these active and voracious animals*.

* Before making this attempt, it seems desirable to make a close examination of the anatomy of the neighbouring genera.

On laying open the ventral region of the head of *Ommastrephes todarus*, the subœsophageal ganglions were soon ascertained to hold their normal position. In this Cephalopod, however, they are divided into three masses, one being placed a little in advance of the other two; but all above the alimentary tube. The anterior (Pl. I. figs. 1, 2, 3 *a*) is a depressed, irregularly circular mass, giving off from the anterior border, on each side of the median line, five large nerves (*o*, *o*) to the arms, and from the posterior margin on each side two small ones (*t*, *t*), which were lost in the muscular mass in front of the eyes. A commissure (*c*) running backwards connects this with the second or median mass, and is a very thick cord composed of numerous stout filaments, most of which pass over the ventral surface of the anterior ganglion, and becoming united to the brachial nerves accompany them into the arms. Thus each arm receives a nerve from the median as well as from the anterior masses. A central filament was lost in the substance of the anterior mass.

As soon as the brachial nerves enter the root of the arms they swell out a little, each forming an indistinct oval ganglion (fig. 2, 3 *p*, *p*); these ganglions are united with each other by nervous cords, and thus a complete chain of nerves and ganglions encircles the oral channel. The brachial nerves (*o'*, *o'*) are continued on from the ganglions to the extremity of the arms within a central channel, giving off filaments on either side, several of which pass through the substance of the organ and go to the skin. The surface being thus copiously supplied with nerves is probably highly sensitive. Filaments are given off from the ganglionic chain at the base of the arms; these filaments pass inwards and enter the muscular bands that tie the oral lamina to the arms. This lamina arises from the wall of the oral channel, and advancing embraces the fleshy fringe which immediately surrounds the beaks; it is then turned back upon itself, and forms a broadish scalloped membrane having points or rays which are rather thick and fleshy. These rays correspond to the muscular ties; and on the nervous filaments from the ganglionic chain entering the bases of the rays, they become united to elliptical ganglions (*q*, *q*), from which the nerves (*q'*, *q'*) much enlarged are continued to the extreme points of the rays. These ganglions and nerves distribute numerous filaments which ramify over the oral membrane; the branches are most plentiful towards the points of the rays. This membrane, which corresponds very well with the external and internal labial processes in *Nautilus*, is probably an organ of taste, the sense being more particularly located in the points or rays; it is moreover supplied with numerous large oval follicles, mostly associated in pairs, and having one of their extremities opening by several pores on the

surface; these are probably for the purpose of secreting saliva or mucus.

The median mass (Pl. I. figs. 1, 2, 3 *b*) is somewhat depressed, long, narrow, and divided by a median depression in the longitudinal direction. At the upper surface two large nerves (*i*) are given off to the funnel; these nerves spread out in the substance of that organ in a radiating manner. Immediately behind the origin of the funnel nerves the auditory nerves (*j*) come off; each of these is short and passes at once to the auditory sac, which is protected within a cavity in the cartilaginous cranium. The sac completely fills the cavity, and has the inner surface studded with a few tubercles apparently of soft pulpy matter. The minute calcareous otolithe (Pl. II. fig. 4), which also adheres to the inner surface of the sac, is depressed, rounded, and enlarged at one end, and produced into a slightly curved point at the other. The median mass gives off from the anterior margin the great commissure (*c*) that connects it to the anterior mass, and is united above to a broad nervous collar which closely embraces the œsophagus. On the opposite side of the collar, above the alimentary tube, are developed the optic ganglions (Pl. I. fig. 3 *l*, & Pl. II. figs. 1, 2, 3 *i*); they are fused into one, rounded and prominent behind, and produced into an obtuse point before; a slight depression sufficiently indicates its bilateral formation. Each half gives off from its outer margin a large, broad, depressed nerve (Pl. I. figs. 2, 3 *k*, & Pl. II. figs. 1, 2, 3 *j*), which, as it approaches the posterior wall of the eye, is surrounded by a thick fold (Pl. II. figs. 1, 2 *k*) of ganglionic matter; this fold, as well as the nerve, is striated; the former breaks up into numerous filaments (Pl. II. fig. 3 *n*, *n*), which, spreading over the back of the eye-ball, supply the *retina*. The optic ganglions are also directly connected with the median nervous mass, as can be seen by laying open the œsophageal collar, and removing the membrane or sheath. Thus we find that the anterior and median are in connexion with all the organs of the senses that have yet been clearly determined in these animals, and the curious mode in which they give off the brachial nerves would seem to prove that they form but one centre. If this be doubted, however, it is only necessary to refer to other species* to show that such is really the case.

In Cuvier's memoir on the Cephalopods it is stated, and the parts are figured, that the nerves of the arms, funnel, and auditory organs are all supplied by a single pair of large ganglions, which by commissures are brought into connexion with the optic centres, evidently much in the same manner as in *Ommastrephes*. And Professor Owen has shown that in the Pearly Nautilus the arms or tentacles, and funnel, derive their nerves from a single

pair of large ganglions, the anterior subœsophageal of that author; these ganglions are also in connexion with the optic centres, although they are stated to come off from the "commis-sure or brain": the auditory organs were not determined. It may therefore be concluded, that however divided in *Ommastrephes*, the anterior and median masses form essentially only one centre.

The position of the optic ganglions is also peculiar. In the Gasteropods, when they exist, they are usually attached to the sides of the cerebroids towards their posterior margins, and give off their nerves upwards—the eyes being invariably placed on the dorsal aspect. In the naked Cephalopods they are also inclined towards the dorsal surface, and the ganglions are directly above the alimentary tube, and they as well as the eyes are enormously developed; had these ganglions therefore retained their usual lateral position, the head must have been inconveniently enlarged. In *Nautilus*, however, the optic ganglions may be said to occupy their normal position, for they are placed at the sides of the "anterior subœsophageal ganglions," and are apparently connected with them as well as with the dorsal commissure or brain. What are here denominated optic ganglions have been called by some writers rudimentary optic lobes, by others the rudiment of a brain. It is pretty evident, however, that they are homologous with the optic ganglions of the Gasteropods, in which the nervous element of the visual organ is divided into three parts as in the Cephalopods. Thus, in *Doris* for instance, there is first a minute ganglion, generally closely attached to the cerebroid; this is succeeded by a nerve, which, on reaching the back of the eye, is in many Gasteropods, particularly in the Nucleobranchs, spread out as an accumulation of nervous matter, which, being the third portion, would appear to correspond to the enlargement of the nerve at the back part of the eye in the Cephalopods.

The anterior subœsophageal mass of *Ommastrephes* gives off from its posterior margin above two nervous cords (Pl. I. figs. 1, 3 *m*, & Pl. II. fig. 2 *g*), one on each side of the median line; these passing upwards and forwards, one on each side of the œso-phagus, go to be united to the posterior margin of a pair of rather small, depressed ganglions (Pl. I. fig. 1 *j*, & Pl. II. figs. 1, 2 *d*) adhering to the outer capsule of the buccal mass, forming the buccal retractors, to which these centres send all their nerves (Pl. I. fig. 1 *p*, & Pl. II. fig. 2 *e*, *e*), which are numerous, and passing forward spread out in a radiating manner. These ganglions are fused into a transversely elongated mass comprising two lateral lobes, and are interconnected with another pair of similar ganglions (Pl. I. fig. 1 *k*, & Pl. II. fig. 1 *e*) lying on the

buccal mass immediately below the origin of the œsophagus; the cords (Pl. I. fig. 1 *l*) which unite them pass therefore downwards inclosing that tube, and are joined to the external margins of both pairs. The under pair of buccal ganglions give to the buccal organ four pairs of nerves; the pair (*r*) next the median line go to the tongue and the fleshy laminae on each side of it, which laminae being in connexion with the salivary glands and themselves glandular, must be looked upon, if not entirely, at least to some extent, as auxiliary to them; the next pair (*q*) go to the muscles of the under jaw and anterior part of the buccal organ; the outer or external pair (*q'*) supply the muscles of the upper jaw. These three pairs come off from the anterior margin; the fourth pair (*s*) pass off from behind on the median line, and are applied to the under surface of the œsophagus, and accompanying that tube backwards they form a plexus of minute twigs on it, and go to be united to a ganglion on the stomach. This pair of nerves is similar to that which in *Doris* has been considered to represent the *par vagum* of the higher animals. It appears that these four ganglions are the homologues of the buccal ganglions,—the centres which in the Gasteropods supply the tongue, the muscles of the buccal mass, and the salivary glands, and also give off the two œsophageal nerves. But here again, as with the centres which supply the brachial nerves, there are two pairs instead of one, and one of them is placed below the alimentary tube. It is pretty certain, however, that they are only the buccal ganglions, broken up, probably on account of the peculiar arrangement of the parts they supply.

In *Nautilus*, “the parts immediately surrounding the mouth, the muscles of the jaws, and the tongue,” take their nerves from the broad “rounded chord or commissure” placed transversely above the œsophagus, and connected by its extremities to the optic and to the great ganglions below that tube. This commissure Professor Owen calls the brain, and considers it analogous with what we have denominated the optic ganglions in the Cuttle-fishes. It would seem, however, that as this commissure in *Nautilus* gives its nerves, four pairs, to the buccal mass and tongue, it is homologous with the four buccal ganglions of *Ommastrephes*. And thus it appears that the buccal ganglions of *Nautilus* are situated above the œsophagus. In the Gasteropods they are always below it.

In the Cephalopods the buccal ganglions are also connected to the optic. A delicate cord (Pl. II. figs. 1, 2 *h*) is given off from the anterior apex of these ganglions in *Ommastrephes*; it passes from the upper side on the median line, and is composed

of two filaments which soon diverge, and passing forwards above the œsophagus go to be united to the posterior margin of the upper pair of buccal ganglions.

This connexion of the optic with the buccal ganglions has not been observed in the Gasteropods; but it is possible enough that such connexion may exist, for the commissure which unites the buccal to the cerebroid in these animals leaves the latter not far from the attachment of the optic ganglions. Yet it must be expected that in the lower mollusks some deficiencies with regard to the optic apparatus exist, when the low state of their visual power is compared with its perfection in the Cephalopods.

There is another apparent anomaly in respect to the optic ganglions of *Ommastrephes*. Other two cords or commissures would seem to be given off from the apex of these centres. These cords (Pl. I. figs. 1, 2, 3 *d, d*, & Pl. II. figs. 1, 2 *c*) issue from the sides of the apex and from the under surface; but on close examination have all the appearance of being connected to the median subœsophageal centre through the commissure which unites the latter to the optic ganglions. This, however, was not perfectly demonstrated, though there can be little doubt of the fact. These cords course forwards above the œsophagus, having the optic commissure, just described, between them, and are joined to the upper and posterior margin of the anterior subœsophageal mass close to and behind the roots of the cords which unite this centre to the buccal ganglions. Now it has already been shown that there exists a peculiar connexion between the anterior and median masses below the œsophagus; it is therefore a matter of some interest to ascertain what is the nature of this second union. That first described was effected, it will be recollected, by a cord composed of numerous stout filaments, most of which, though attached to the under surface of the anterior ganglion, did not appear to enter it, and that becoming joined to the brachial nerves from this centre entered the arms in union with them. Thus the nerves that supply these organs are derived from two sources,—have in fact two roots, arising much in the same manner as the sensitive and motor roots of the spinal nerves of the *Vertebrata*. I have observed something of the same sort in the Gasteropods; in *Thetis*, the nerves supplying the veil appear, on passing from the cerebroid ganglions, to have two roots.

The sensitive and motor influences in the *Mollusca* must be assumed to reside in all the ganglions. And here it may be asked, do we not see, in the peculiar manner with which the brachial nerves are supplied in this Cephalopod, something almost approaching to a proof of the fact that these powers have even in the *Invertebrata* their own peculiar centres? The anterior mass

would appear to be the source of the motor power of the parts it supplies, while the median, being in connexion with the organs of sense, is probably more particularly the seat of sensation, and the nerves therefore it gives to the arms, sensitive. This interesting part of the subject requires further investigation; but from what has just been stated, it would seem that the ventral connexion of the two subœsophageal masses can scarcely be looked upon in the ordinary light of a commissure; and thus it would appear that the second union,—that passing above the œsophagus, and coming apparently from the apex of the optic ganglions, is the true commissure between the anterior and median subœsophageal masses.

The third or posterior subœsophageal nervous centre is broad and trilobed, and is attached to the posterior margin of the median centre, and is consequently situated close under the œsophagus. The exact mode of attachment could not be determined with sufficient accuracy; but it seems to be effected by a fusion of the lateral parts with the commissure uniting the optic to the median subœsophageal mass; and as the great collar around the œsophagus seems to be formed of three portions, there can be little doubt that the lateral parts of this ganglionic mass are also united above that tube.

This mass is represented in *Octopus* by a large flat ganglion, forming as it were the posterior portion of the mass giving off the brachial nerves; and in *Nautilus* by what has been designated the posterior subœsophageal ganglions.

In *Ommastrephes* the mass is indistinctly formed of three ganglions, the homologues of the visceral and branchial of the Gasteropods; the visceral (Pl. I. figs. 1, 2, 3 *e*) appears to be single, and is placed between the two branchial (*f, f*). These ganglions vary very much in form and situation in the lower mollusks, being sometimes above and sometimes below the œsophagus; but the visceral are always connected to the branchial, and the latter to the cerebroids and pedial, and it frequently happens that there is apparently only one visceral ganglion, which is placed between the branchial exactly as in *Ommastrephes*. A similar arrangement occurs in *Onchidium* and *Vaginulus*, and in these mollusks they are situated below the œsophagus. The branchial ganglions of the Gasteropods have been so named, because they are deemed homologous with those of the same name in the *Lamellibranchiata*; and because in *Doris* they send a filament to the branchio-cardiac ganglions of the sympathetic system; and moreover they furnish nerves to the mantle, which, perhaps, in all the *Mollusca* is accessory to the special breathing organs.

Each of the branchial ganglions (Pl. I. figs. 1, 2, 3 *f*, & Pl. II. fig. 1 *o*) of *Ommastrephes* gives off posteriorly a large nervous cord (Pl. I. fig. 1 *h*, *h*), which on its passage to what has been called the stellate ganglion distributes two or three nerves. The first (Pl. I. fig. 1 *u*) of these passes off almost immediately to the muscles of the mantle a short way behind the head; a little further down another branch (*u'*) is given off, which, dividing into two portions, sends one of them to the mantle—the membrane investing the viscera. The other (*w*), which is the larger, becomes attached to the anterior aorta; and after supplying this great vascular trunk with numerous twigs, follows a branch of it into the liver, where it was lost. This is the course of this nerve on the right side. A similar nerve (*w'*), from the cord of the left side, is also applied to the aorta; but how it terminates was not ascertained. Close to the root of the great nervous cord, on the inner side, another pair of nerves (*u'*) leaves the branchial ganglions. These nerves go to the muscles forming the sides of the mantle in front, and to the posterior portion of the funnel. Professor Owen considers these muscles in the Cuttle-fishes to represent the shell-muscles of *Nautilus*; accordingly this nerve, and the two above described as going from the great cord to the mantle, are all that in *Ommastrephes* represent the numerous nerves given from the posterior “sub-oesophageal” (branchial) ganglions to the shell-muscles in *Nautilus*. The comparative, almost rudimentary, condition of these nerves in the naked Cephalopods is naturally accounted for by the rudimentary state of the muscles they supply. A similar reduction of the nervous element is always found when the organ is imperfectly developed, as can very easily be proved by the dissection of a few Gasteropods whose organs are of unequal development. There are, however, other two or three small nerves (Pl. I. figs. 1, 3 *v*, *v*, & Pl. II. figs. 1, 3 *m*) given off from either side, apparently from the upper surface of the optic nerve, close to a small, round, ganglionic enlargement (Pl. II. fig. 3 *l*), which nerves, perhaps, should be considered as belonging to the branchial ganglions; and if so, the ganglionic enlargements must be accessory branchial ganglions. These nerves go to the skin of the head above and behind. The ganglionic enlargements may, however, represent the olfactory ganglions, which, in the Gasteropods, are not uncommonly confounded with the optic nerve, as for instance in the *Bullidæ*; and if so, the olfactory organ is probably situated in the vicinity of the eye;—a conclusion not altogether improbable, for in *Nautilus* the ophthalmic tentacles have the structure of the dorsal tentacles of *Doris*, which tentacles are assuredly the seat of olfaction. I did not succeed,

however, in detecting near the region of the eye of *Ommastrephes*, any organ likely to be the seat of this sense.

The great visceral nerves (Pl. I. figs. 1, 2, 3 *z*), combined as one trunk, come off from the posterior margin of the visceral ganglion, forming the central lobe in the posterior mass. But it is better to defer the description of these visceral nerves until we come to speak of them under the head of Splanchnic system. We will therefore without further interruption examine the only remaining pair of cephalic ganglions. These are the stellate ganglions (Pl. I. fig. 1 *g, g*) of authors; they are large, depressed and irregularly ovate, and rest upon the great muscular envelope—the sleeve, one a little on each side of the median line, not far from the anterior border, and having the cyst containing the pen between them. These ganglions are connected to the branchial by a stout commissure (*h, h*) which comes off from these latter, as before stated, in connexion with two or three nerves, which we have seen distribute most of their filaments to the mantle. This commissure is united to the anterior margin of the stellate ganglions, and they communicate with each other across the median line by a stout nervous cord (*i*), which passing from their inner margins goes through the wall of the cyst inclosing the pen; at this part the wall of the cyst is thick and fleshy. This latter cord or commissure, which appears hitherto to have escaped detection, is of course above the œsophagus. Were therefore the stellate ganglions only accessory branchial, they would have no connecting commissure above that tube. These ganglions distribute to the sleeve numerous nerves (*y, y, y, y*) which pass off from their outer margin in a radiating manner. The fins are supplied from a different source. Just before the great branchial cord reaches the stellate ganglion it gives off a stout nerve (*x' x'*) which passes freely under that centre, and becomes united to the great posterior sleeve nerves (*x, x*); as they pass backwards together these latter distribute their filaments to the sleeve, and on arriving at the commencement of the fin, the large nerve from the branchial cord dips through the muscles and reaches the substance of that organ; it then divides at once into numerous branches, which diverging go to all parts of this powerful propelling instrument.

The fin is then supplied with nerves, not from the stellate ganglions, but apparently from the branchial. From this fact, it would seem that the fin is not a mere development of the sleeve, but must represent some other organ. What this is it is difficult to say.

As the fin nerves pass backwards in connexion with those of the posterior portion of the sleeve, they have, on account of their central position, their parallelism and approximation, somewhat

the appearance of a rudimentary spinal cord, as has been before remarked. But certainly they resemble nothing so much as the posterior trunks of the pedial nerves of some of the Gasteropods, — of *Vaginulus* in particular. In that species the great pedial nerves pass along the median line closely approximated, and associated with the visceral and some of the branchial nerves. This cord, so to speak, gives off filaments on either side as it passes backwards, and might very aptly be compared to a spinal cord were its true nature not fully understood. The anterior pedial nerves of this animal come off from their ganglions in a similar radiating manner to those of the stellate ganglions of the naked Cephalopods.

Having now gone over the cephalic ganglions of *Ommastrephes*, we have next to examine the splanchnic system, and this will be found to agree in all essential features with the same portion of the nervous system in the Gasteropods. The great visceral nerves (Pl. II. fig. 1 *q*) are two in number; these, as before stated, come from the visceral ganglion situated between the branchial. At first these nerves form but one trunk, which is however distinctly composed of two filaments; they soon divide and resolve themselves into four branches; but previously give off two minute twigs (*q'*, *q'*), one on each side, which go to the mantle. Two (*t*) of the four branches becoming attached to the wall of the anterior vena cava, pass down that vessel as far as the pericardium, where they unite to form a large, depressed, irregularly quadrilateral ganglion (*u*) which gives off four branches. The two larger (*v*, *v*) of these diverging enter the root of the gills, and after giving a branch to the branchial vein swell out to form, on the wall of each branchial artery, an oval ganglion (*v'*, *v'*), from which a stout nerve passes up the organ, supplying it with a plexus of filaments as it goes. These two branches from the ganglion on the vena cava give off in their course each a nerve or two (*w*, *w*) which go to the generative organs. One (*x*) of the other two branches from this ganglion accompanies the vena cava into the pericardium, and passing along with that vessel sends branches to the two branchial hearts, to the systemic heart, and to the posterior aorta.

The other pair (*r*) of visceral nerves from the great trunk come off from one of the branches given to the vena cava as a single stem, which almost immediately forming a small ganglionic swelling (*s*), divides into two branches. These are not so large as those applied to the vena cava; they become at once adherent to the intestine, and tube of the ink-bag, and supply to the walls of these organs a minute nervous plexus most developed towards the orifices of the tubes. These two nerves were traced as far downwards as the ink-bag, where they were lost in

the investing membrane. These four branches of the visceral nerves, the ganglion on the vena cava, and the gastric ganglion to be shortly described, have usually been considered as all that represent in the Cephalopods the *par vagum* and sympathetic system of the higher animals. This, however, is not correct. It has been already stated that the buccal ganglions give off a pair of œsophageal nerves, which passing down that tube give to it a plexus of nervous filaments. These two nerves (Pl. II. fig. 1 F, F) leave the ganglions as one trunk passing from the median line, and are at first applied to the under wall of the tube; they soon, however, divide and approach the sides, and in their course appear to turn completely round the œsophagus. On attaining its lower extremity they go to be united to a considerable elliptical ganglion (*z*), situated on the first stomach or gizzard close to the cardia. From this gastric centre various nerves ramify. Two or three small twigs (E) are given off close to the œsophageal nerves, and are applied to the cardiac portion of the gizzard. From the opposite side of the ganglion a stout nerve (A) goes to the spiral stomach, and two or three large nerves issue from the ends of this centre; those (B, B, B) from one of the extremities, three in number, go to the gizzard; those from the other originate as one trunk, but soon separate into three branches; two of these (C, C) supply the pancreatic organ, and one (*y*) is continued on to be joined to the ganglion on the vena cava, forming the fourth cord issuing from that centre. A small twig (D) also springs from this end and supplies the pylorus.

We see then that the nerves applied to the anterior aorta, and those from the visceral ganglion, and their dependencies, represent only the splanchnic or sympathetic system of the higher animals; while in the œsophageal nerves are found the analogues of the gastric portion of the *par vagum*. And it is interesting to observe that these two parts of the nervous system—one originating in the visceral, the other in the buccal ganglions, exactly as in *Doris*,—are interconnected by a nervous filament in the same way as they are in that mollusk. The single gastric ganglion in *Ommastrephes* represents the principal centre of the collar of ganglions about the cardiac extremity of the stomach in *Doris*, and the ganglion situated on the vena cava, and those attached to the gills, are the equivalents of the branchio-cardiac and genital centres of that animal. It is therefore evident that this division of the nervous system of the Cephalopod is formed on the type of that of the Gasteropod; the only difference being that the ganglions are much less numerous than in *Doris*. In other Gasteropods, however, these centres are frequently very limited in number.

The cephalic portion, though exhibiting several deviations, is

also in general character molluscan. The Cephalopods, however aberrant in external appearance, would therefore seem to be true mollusks.

On taking a glance at the vascular system, the same conclusion is inevitable. Milne-Edwards states, in his article on the circulation of the "Poulpe," that the arterial system of the Cephalopods is fundamentally the same as in the Gasteropodous and Acephalous mollusks; and the heart itself, though considerably modified, he assimilates to that of the *Acephala*. It is truly systemic, having superadded, to meet the changed and active habits of these creatures, additional propelling organs appended to the gills*. In *Nautilus* these latter are deficient, the central apparatus being reduced to a true molluscan ventricle. There is no true pericardium, and the great chamber in which the blood-propelling organs are placed appears to represent the renal cavity in *Doris*; but whether truly so or not, it is probably of the same functional purport. The glandular nature of the walls of the great venous trunks congregated in that chamber cannot fail to suggest the idea that it is designed for the reception of some copious outpouring from the blood; and as it opens externally by two minute orifices at the roots of the gills, its similarity to the renal organ in *Doris* is almost complete. The portal heart, which in that mollusk is connected with this organ, is indeed at present not determined, though it is very likely that the two "fleshy organs" appended to the branchial hearts will prove to be ventricles for propelling venous blood into the liver. These fleshy organs in *Ommastrephes* were examined and found to be hollow, muscular and heart-like, communicating through their pedicle with the branchial hearts, and having the orifice guarded by a valvular constriction. The free side is perforated in the centre, the lips of the orifice being jagged as if torn from a vascular attachment. There can be little doubt that these are organs for propelling blood, and that too in a venous state, and to determine this fact, all that is wanting is a favourable opportunity; but it unfortunately happens that the region of the heart is most liable to laceration; the specimens examined in this instance were ruptured in that locality by rough handling when captured.

Thus we see that the vascular system of the Cephalopods is likewise formed on the molluscan type, and the digestive system

* These are not the only additional blood-propelling organs in *Ommastrephes*. The posterior aorta previous to sinking into the fin is divided into two branches, which, as they penetrate the fleshy substance, are each dilated into a small but well-defined ventricle; these ventricles will undoubtedly throw the blood with increased force into this powerful muscular organ.

leads to the same conclusion. We shall not, however, on this occasion endeavour to trace out the homologies which we believe to exist between the organs of the Cephalopods on the one hand, and the organs of the rest of the Mollusca on the other. To this important and highly interesting subject we hope to return, when a more extended knowledge of the anatomy and physiology of these highly organized animals shall have enabled us to speak with sufficient confidence.

EXPLANATION OF PLATES I. II.

PLATE I.

Fig. 1. Ventral view of the cephalic ganglions and nerves of *O. todarus* :—*a*, anterior subcesophageal mass; *b*, median ditto; *c*, their under commissure; *d*, upper ditto; *e*, visceral ganglion; *f, f*, branchial ditto; *g, g*, stellate ditto; *h*, cords or commissures uniting same to branchial ganglions; *i*, transverse commissure of stellate ganglions; *j*, upper buccal ganglions; *k*, lower ditto; *l*, commissure uniting the two pairs of buccal ganglions; *m*, commissure uniting upper buccal ganglions to anterior subcesophageal mass; *n*, commissure between the same buccal ganglions and optic ganglions; *o, o*, brachial nerves; *p*, nerves to muscles of outer buccal capsule; *q, q'*, nerves to muscles of buccal mass and jaws; *r*, lingual nerves; *s*, cesophageal nerves or par vagum; *t, t*, two pairs of small nerves lost in muscles in front of the eyes; *u, u', u''*, nerves to the mantle and its muscles; *v, v*, two pairs of nerves to skin of head above and behind; *w, w'*, nerves applied to the anterior aorta; *x, x*, great posterior sleeve nerves; *x', x'*, nerves to fin; *y, y*, sleeve nerves; *z*, visceral nerves.

Fig. 2. Enlarged view of anterior and median subcesophageal, visceral, and branchial ganglions :—*a*, anterior mass; *b*, median ditto; *c*, under commissure of same; *d, d*, upper ditto; *e*, visceral ganglion; *f, f*, branchial ditto; *h, h*, commissure uniting branchial and stellate ganglions; *i*, nerves supplying funnel; *j*, auditory nerves; *k, k*, optic ditto; *o, o, o', o'*, brachial ditto; *p, p*, ganglionic swellings of same; *q', q'*, nerves to oral lamina, exhibiting ganglionic swellings *q, q*; *t, t*, two pairs of nerves to muscles in front of eyes; *u, u*, nerves to mantle; *z*, ditto visceral.

Fig. 3. Side view of anterior and median subcesophageal, optic, branchial and visceral ganglions :—*a*, anterior mass; *b*, median ditto; *c*, under commissure of same; *d*, upper ditto; *e*, visceral ganglion; *f*, branchial ditto; *g, g*, cesophagus; *h, h*, commissures uniting stellate and branchial ganglions; *i*, nerves to the funnel; *j*, auditory nerves; *k*, optic ditto; *l*, optic ganglions; *m*, commissure between upper buccal ganglions and anterior subcesophageal; *n*, ditto uniting optic and upper buccal ganglions; *o, o, o', o'*, brachial nerves; *p, p*, ganglionic swellings of same; *v*, two pairs of small nerves to skin of head above and behind.

PLATE II.

Fig. 1. View of splanchnic nervous system seen from above :—*a*, anterior subcesophageal mass; *b*, under commissure uniting same to median subcesophageal; *c, c*, upper commissure of same; *d*, upper buccal ganglions; *e*, under ditto; *f*, commissure uniting the two

pairs of buccal ganglions; *g*, ditto uniting upper buccal ganglions to anterior subœsophageal; *h*, ditto uniting upper buccal ganglions to optic ditto; *i*, optic ganglions; *j*, optic nerves; *k*, enlargement of same at back of eye; *l*, small round ganglion attached to optic nerve; *m*, two pairs of nerves from same; *n*, visceral ganglion; *o*, branchial ditto; *p, p*, cords or commissures from same to stellate ganglions; *q*, visceral nerves; *q', q'*, nerves to the mantle; *r*, pair of visceral nerves applied to intestine, and tube of ink-bag; *s*, small ganglion at origin of this pair of nerves; *t*, another pair of visceral nerves supplying the anterior vena cava; *u*, ganglion on the wall of vena cava; *v, v*, branchial nerves, each exhibiting a ganglionic swelling *v'*; *w, w*, genital nerves; *x*, nerve supplying systemic and branchial hearts and posterior aorta; *y*, cord or commissure uniting gastric ganglion to that on vena cava; *z*, gastric ganglion; *A, A*, nerve to spiral stomach; *B, B, B*, nerves to gizzard; *C, C*, ditto to pancreatic organ; *D*, ditto to pylorus; *E*, ditto to cardia; *F, F*, œsophageal nerves or par vagum.

Fig. 2. Under view of anterior subœsophageal and optic ganglions:—*a*, anterior mass; *b*, under commissure connecting same to median; *c, c*, upper ditto; *d*, upper buccal ganglions; *e, e*, nerves supplying the outer buccal capsule; *f*, commissure between same and lower buccal ganglions; *g*, commissure from upper buccal ganglions to anterior subœsophageal mass; *h*, ditto from optic to upper buccal ganglions; *i*, optic ganglions; *j, j*, optic nerves; *l, l*, small round ganglions on same; *m, m*, brachial nerves; *n*, two pairs of nerves to muscles in front of eyes.

Fig. 3. Upper view of optic ganglions:—*i*, optic ganglions; *j, j*, optic nerves; *k, k*, enlargement of same at back of eye; *l*, small round ganglions on optic nerves; *m, m*, nerves from same to skin of head above and behind; *n, n*, filaments from optic nerve applied to back of eye; *o*, eye.

Fig. 4. Otolithe from auditory sac.

II.—*A few Notes on the Structure of the Belemnite.* By GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S., President of the West London Medical Society, &c.

To the Editors of the Annals of Natural History.

“Dr. Mantell, who has adopted Mr. Channing Pearce’s generic name of *Belemnoteuthis* for some of these fossils (*Belemnites*), seems to be disposed to detract from the merit of their anatomical restoration, for which the Royal Society awarded the Royal Medal to Professor Owen in 1848, affirming that the true characters of the animal of the *Belemnite* have yet to be discovered. But he forgets that a change of name does not change the essence of a thing, and that the essential character of a *Belemnite* is the *phragmocone*.”—From the Article entitled “Progress of Comparative Anatomy,” Quarterly Review, March 1852, p. 383.

GENTLEMEN,

THE personal imputation, the mystification of the point at issue, and the misstatement respecting the late Mr. Channing Pearce,