

its characters are so well marked that we need not wait till it shall be found in abundance, as it probably will some day. It would, however, certainly have been overlooked in Lochleven, but for the minute search to which the gathering was subjected. The same remarks apply to *Navicula lacustris* and to *Navicula lepida*.

Whenever, therefore, a gathering is met with which appears to contain a great variety of forms, like the four above mentioned, it should be systematically and minutely searched, and any striking forms, no matter how scarce, noted and figured. If true species, they will most probably be found in greater abundance elsewhere.

It is much to be regretted that no work yet published contains figures of all the known species or forms named as species by their observers. Even in Ehrenberg's last great work, in which many hundred species are figured, I observe the names of about 350 species, most of which are described as remarkable or characteristic of certain localities, not one of which is figured, although most of the common species are many times represented.

Supposing, then, that all those forms which I have just described as new to science should prove to be good and distinct species, of which I cannot, of course, be sure, it is out of my power to ascertain whether they may not agree with some of the species named, but not figured, in his last work, by Ehrenberg. I ought to mention, however, that several of the species of my first section, new to Britain only, were considered by myself and others as new to science, till I found them figured in Ehrenberg's 'Microgeologie,' when of course I adopted his names for them.

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*An Account of the STRUCTURE and RELATIONS of SAGITTA  
BIPUNCTATA. By G. BUSK, F.R.S.*

THE minute creature to which the above name has been given, though abundant, perhaps, in all seas, and noticed so long ago as in the year 1781, has received but little attention from zoologists in general. Its curious and interesting structure, however, and doubtful position in the animal kingdom, render it a subject well worthy of further research; and its minute size, and the extreme delicacy and transparency of its tissues, make it peculiarly an object of microscopical investigation. Though perhaps unknown, even by sight, to many of our readers, the *Sagitta bipunctata* will probably be met with on every part of the coast; and it may be procured,

without difficulty, at any rate in fine and calm weather, by means of a small muslin towing net over the side of a boat.

The animal, which has the form of a pointed needle, is from one to two inches in length or less, and transparent as the clearest glass. In warm, calm weather it swims on the surface of the sea, and occasionally in the most surprising numbers. In these latitudes it appears to be in a state of the most complete maturity in August and September.

The present account pretends to little originality, except in the figures, some of which were made by myself in 1852, from specimens taken in Sandown Bay in the Isle of Wight; and for others, I am indebted to [Mr. Huxley, whose observations upon this creature were made in the course of the voyage of the 'Rattlesnake' in the seas of Australia. That accurate observer, who has also studied the British form, is of opinion that the *Sagitta* he examined in the southern hemisphere and elsewhere, is identical with that found on our coasts; and I have, therefore, no hesitation in availing myself of his figures, illustrating the nervous system.

The earliest notice of the animal which forms the subject of this paper was given by Martin Slabber\* in 1781, by whom also the very appropriate name of *Sagitta* was applied to it. This notice, however, seems to have been forgotten until M.M. Quoy and Gaimard, when commencing their second voyage round the world, re-discovered the animal, as it may be said, in the Straits of Gibraltar. The species observed by them was named *Sagitta bipunctata*, and is probably identical with that now under consideration. This form and other species of the same genus have been since noticed and more or less accurately described and figured by several authors, amongst whom may be noticed Scoresby,† D'Orbigny,‡ Forbes,§ Darwin,|| Krohn,¶ Wilms,\*\* Huxley†† and Busch.‡‡

\* 'Physikalische Belustigungen, oder mikroskopische Wahrnehmungen von 43 in- und ausländischen Wasser- und Landthierchen.' Nurnberg, 1781.

† 'Account of the Arctic Regions,' vol. ii., Plate XVI.

‡ 'Voyage dans l'Amerique meridionale; Mollusques, p. 140, Plate X., figs. 1—7.

§ 'Annals Nat. Hist.,' 1843.

|| 'Annals Nat. Hist.,' 1st Ser., vol. xiii., p. 1.

¶ 'Anatomisch-physiologische Beobachtungen ü. die *Sagitta bipunctata*,' 1844. 'Nachträgliche Bemerkungen ü. den Bau der Gattung *Sagitta*, nebst der Beschreibung einiger neuen Arten.' (Wiegmann's 'Archiv.,' 1853, p. 266, Plate XII.) And Müller's 'Archiv.,' 1853, p. 140.

\*\* 'Observaciones de *Sagitta*, mare Germanicum circa insulam Helgoland incolente,' 1846.

†† Report of British Association, 1851. (Trans. of Sections, p. 77.)

‡‡ Beobachtungen ü. d. Anatom. u. Entwicklung einiger wirbello. Seethiere, 1851, p. 93.

The present account of the animal, however, has been compiled chiefly from the observations of Krohn and Wilms, whose papers on the subject appear to include nearly all of importance that has as yet been made out respecting the anatomy and physiology of *Sagitta*.

The body of the *Sagitta bipunctata* is as transparent and clear as glass, cylindrical or slightly flattened, pretty regularly fusiform, though rather more attenuated posteriorly than in front (Pl. II. fig. 1), when it again expands at the extremity. It is divided into three distinct portions, the "head," "trunk," and "caudal portion," which are separated from each other by transverse septa. Each of these portions will be separately described. Posteriorly the body is furnished, on the sides and extremity, with five delicate membranous expansions, which have received the name of "fins," though bearing no real analogy with the fins of a fish. These "fins" are all in the same plane, and spring from a line equidistant between the dorsal and ventral surfaces. The anterior pair of lateral fins, which are far smaller than the posterior, are situated nearly in the middle of the body, being equal in length to about 1-5th of the extreme length of the animal. The posterior pair of lateral fins, which are both longer and wider, extend from the posterior border of the former to within a short distance of the caudal extremity, where they terminate rather abruptly. Anteriorly the two pairs of fins are often apparently continuous with each other by a very narrow band of similar texture; so that, in fact, in many cases the lateral fins might be described as constituting only one pair, of varying width in different parts. The caudal fin is, however, quite distinct. It is broad and somewhat rounded, expanding like a fan from the posterior extremity of the body, and passing a short distance up on each side. These "fins" are composed of an excessively delicate and apparently structureless membrane, which is strengthened by very slender radiating fibres, placed very closely together, and appearing to be somewhat thicker at the base than more outwardly. Although very slight injury tears the fin in the direction of these apparent fibres—and its edge, thence, often appears to be fimbriated—the fibres themselves cannot be readily isolated, and there is every reason to believe that the edge of the fin in the perfect state is entire.

The integument, except on the head, is comparatively speaking thick and dense. It is covered with a very delicate epidermis, composed of rounded or polygonal cells. The existence of this epidermis was denied by Krohn in his first

memoir, but is admitted by him in his subsequent observations. When the animal is placed in spirits of wine, the surface presents numerous distinct, whitish, well-defined spots, which closer examination shows to be rounded eminences belonging to the cellular epidermis, and from which project minute bundles of excessively delicate, rigid filaments or *setæ*. These spicules, as they may be termed, were first pointed out by Wilms,\* and the species on that account was termed by J. Müller, *S. setosa*; but from Wilms' description it appears to differ in no important particular from *S. bipunctata*. Wilms describes them as constituting a single series on each side, whilst Busch,† in speaking of a form termed by him *S. cephaloptera*, notices that they are disposed, in that species, in a double series on each side. Krohn also remarks that he has seen these spicular bundles, not only in *S. bipunctata*, but in several other species also; their existence, therefore, would seem to be general throughout the genus, and careful observation may, perhaps, educe from their disposition specific characters of some importance. In *S. bipunctata*, the spicules project on all parts of the body, but they appear to be more numerous on the anterior portion than elsewhere. So far as I have observed, they seem to be scattered irregularly over the surface, although Krohn states that they are apparently arranged in symmetrical longitudinal tracts on the two sides. He says also, that they occur on the caudal fin where they are disposed in a curved line across its width. In some species he remarks that they exist also on the posterior lateral fins.

As has been said before, all these bundles of spicules are placed upon rounded eminences, and in most cases they appear to radiate on all sides from the centre of the eminence; but closer examination will sometimes show that they are disposed in a simple line, and in close contiguity. This is the case, at any rate, according to Krohn, in *S. bipunctata*.

Notwithstanding their rigidity, the filaments, of which these spicular bundles are constituted, have nothing in common either with spines (*aculei*) with which Wilms compares them, nor with *setæ*, as they are termed by Busch. According to Krohn they are epidermic processes. And this notion he remarks is supported by the circumstance that the spicules, like the epidermis itself, are detached with extreme readiness, and consequently are only to be observed in perfectly fresh specimens in a good state of preservation.

Some analogy may, perhaps, be conceived to exist between the filaments of which these epidermic spicules are consti-

\* L. c., p. 11, fig. 1, 16.

† L. c., p. 93.

tuted and those by which the "fins" are strengthened. With reference to the latter, Krohn remarks that after repeated observation he is convinced that these fibres are closely allied to the *setæ* of Annelids. Like these they are flexible to a certain extent, and are readily broken into pieces. In form they exactly resemble the simple or capillary *setæ*. He remarks also, though this hardly accords with my own observation, that they are merely loosely imbedded in the homogeneous substance of the fin; since they may often, in otherwise uninjured "fins," be seen bare for a considerable extent. At any rate their connection with the substance of the fins is by no means so close as he was formerly inclined to believe.\*

Immediately beneath the integument is placed a layer of longitudinal muscles extending uninterruptedly from the head to the caudal portion of the body. These muscles are disposed in two broad bands, one situated on the dorsal and the other on the abdominal aspect, and separated on each side by a clear space, which is brought more distinctly into view, as Krohn remarks, when the muscles themselves are rendered opaque by immersion in spirit. Each band is again subdivided, but less distinctly, into a right and left portion; so that in fact the muscular apparatus might be described as consisting of four bands, a dorsal and an abdominal on either side. These muscular bands are composed of long transversely striated fasciculi resembling those of insects.

The disposition of the muscular apparatus would indicate, as observation shows to be the case, that the movements of the animal are chiefly those of flexion and extension in the transverse plane of the body, and consequently that the *Sagitta*, as was observed by Quoy and Gaimard, swims like a Cetacean by the horizontal blows of its caudal fin upon the water.

The *Nervous system*, in *Sagitta bipunctata*, may be described as consisting of two principal ganglions, one situated on the dorsal aspect of the head, the *cephalic ganglion*, and the other on the ventral aspect of the trunk, the *ventral ganglion*. The one consequently is above the œsophagus, and the other below it,—supra and sub-œsophageal ganglia. These ganglia—which, as well as the nervous trunks, lie immediately beneath, and in close contact with the integument—are mainly composed, as in other instances, of ganglionic cells, but in the ventral ganglion there appears to be a certain amount of white nervous matter in the centre (fig. 8, *h*).

The cephalic, or supra-œsophageal ganglion (fig. 7), is situated in the mesian line, a short distance from the anterior

\* L. c., p. 6.

extremity of the head. It is of a more or less quadrangular form and flattened, in large specimens measuring about  $\frac{1}{4}$  mm. in length. Three pairs of nervous cords proceed from it.

1. An anterior (fig. 7, *bb*) which curves outwards, and then backwards towards the process of the head upon which the buccal hooks are placed, to terminate according to Krohn, in the muscles by which the hooks are moved, close to which, he says, that each nerve presents a minute ganglionic enlargement from which several filaments are given off to be distributed to the muscles.

The posterior pair of nerves arising from the cephalic ganglion (fig. 7, *cc*) pass backwards, in a divergent direction, and terminate in a rounded ganglionic mass, in the centre of which the eye (fig. 7, *h*) is, as it were, imbedded. These optic ganglia, according to Krohn, are composed of distinct ganglionic cells; but it would appear from Mr. Huxley's observations, that the optic nerves, as they may be termed, also exhibit a smaller ganglionic enlargement immediately before entering the optic ganglion (fig. 7, *l*). The optic ganglion and the eye lie in a special closed cavity in the integument of the head.

3. The third pair of nerves arising from the cephalic ganglion (fig. 7, *dd*) are given off from the sides of that body, curving backwards and downwards, so as to pass on either side of, and to get beneath the œsophagus, where they approach each other again, and becoming nearly parallel in the mesian line of the trunk, join the ventral ganglion. They constitute, therefore, what may be termed an œsophageal commissure.

The ventral ganglion (fig. 8) lies in the middle of the ventral surface of the trunk, also immediately beneath the integument, which is seen to be somewhat elevated by it when the animal is viewed on the side. It is situated between the head and the lateral fins, though rather nearer to the latter. It is of an elongated, oval form, and in full-grown individuals about  $1\frac{1}{2}$  mm. long. There may be distinguished in it a lighter-coloured nuclear or medullary substance (fig. 8, *h*), which occupies a central tract, and a darker-coloured, coarsely granular cortical layer, composed apparently for the most part of ganglion-globules. Four principal nervous trunks proceed from this ganglion: an anterior pair (fig. 8, *dd*), which are continuous with the lateral trunks given off from the cephalic ganglion (fig. 7, *dd*), and constitute the œsophageal commissure; and a posterior, (fig. 8, *ff*), which run directly backwards, slightly diverging from each other. These trunks are, upon the whole, stronger and rather shorter than the anterior pair, inasmuch as, according to Krohn, they do not extend much beyond the anterior pair of lateral fins. He states that each trunk terminates

in a sort of *cauda equina*, composed of numerous minute nervous twigs. From the sides of the ventral ganglion, and according to Krohn, from the nervous trunks also, are given off numerous nerves in rapid succession, which, according to the same observer, curve upwards towards the dorsal surface of the trunk, subdividing into numerous twigs, which anastomose, and thus constitute a very intricate plexus beneath the integument. The latter part of this statement may perhaps be erroneous, but at any rate there is no doubt of the fact, that numerous small lateral branches are given off, apparently symmetrically, from the sides of the ganglion itself, as shown in fig. 8.

*The Head.*—This portion of the animal is distinctly separated from the trunk, and is surrounded by a sort of membranous hood, which is capable of being drawn backwards over it. The upper surface of this hood is level with that of the trunk, whilst the lower forms a plane inclined from above, and anteriorly downwards and backwards. When fully expanded, the hood, except inferiorly where it presents, in the middle line, a longitudinal opening for the mouth, appears to envelop the entire head; when retracted, the head is exposed, particularly on the sides, when the following parts are displayed. 1. On each side a series of curved pointed hooks, (fig. 3, c), which, when the hood is expanded, close from either side of the mouth. The number of these hooks does not appear to be very constant, and the anterior hooks are usually shorter than the others. 2. Besides these larger buccal hooks there will be observed, at the anterior extremity of the head, two curved series of smaller denticles (fig. 3, a), one behind the other on either side.

On each side the inferior surface of the head presents a large, rounded eminence, apparently composed of the muscles by which the buccal hooks are more directly moved, and between these buccal lobes is situated the oval opening in the form of a longitudinal slit or fissure, which is crossed posteriorly by a kind of fimbriated border, stretching across from one buccal lobe to the other (fig. 3, b).

The pharynx or œsophagus commencing at this point is a short tube with thick muscular walls, a little larger in diameter than the intestine, and extending but a short distance beyond the junction of the head and trunk. It is bounded on either side by the buccal masses above noticed. On the upper surface of the head, on either side, and pretty close to the median line, will be seen the "eyes," (fig. 7, k). These organs are composed apparently of a mass of black pigment, around the margin of which will be noticed clear points, or *cornæe*,

which, according to Mr. Huxley, are disposed in three distinct sets. As has been before stated, the eyes are lodged in the upper surface of the optic ganglia, and contained together with them in special cavities excavated in the integuments of the head.

2. *Trunk*.—This portion, which constitutes the principal part of the animal, is an elongated hollow sac containing the muscular bands above described, the intestinal canal and termination of the œsophagus, together with the ventral ganglion and its branches, and the ovaries which are situated posteriorly.

The intestinal canal, which commences at the termination of the œsophagus, is a simple, straight, somewhat compressed tube, extending from this point to the junction of the trunk with the caudal portion, where it makes a rather abrupt curve downwards, becomes contracted, and terminates in the anus, which presents the form sometimes of a rounded aperture, sometimes more that of an elongated slit, but in either case projecting beyond the surface. The walls of this simple tube are composed principally of a layer of annular fibres, strengthened on the upper and under sides by a narrow band of longitudinal fibres, which, according to Krohn, are situated external to the annular. The tube is lined internally by an epithelium, composed of elongated prismatic cells, furnished, perhaps throughout, with long vibratile cilia. It is supported in its place above by a continuous median band, and below it is held by numerous slender, usually branched threads, disposed in a line corresponding to the band above. The perigastric cavity is thus imperfectly divided, as it were, into two lateral compartments.

The intestinal canal is generally empty, but in a few instances Krohn has seen in it fragments of minute fish and crustacea, and in some cases portions of other *Sagittæ*.

The "caudal portion," and the ovaries, constitute the *sexual apparatus*, which will now be described.

1. The female portion of this apparatus consists of two organs, which are situated in the posterior part of the cavity of the trunk, on either side of the terminal portion of the intestine (fig. 4, *a, a*, fig. 6). These organs, which may be termed ovaries, in the mature state, are often of considerable size, extending even beyond the upper pair of lateral fins. They are elongated sacs, which are attached by a longitudinal band to the lower wall of the trunk. Inferiorly the ovary curves abruptly upwards and outwards, forming a sort of short oviduct, which opens externally between the upper muscular band and the base of the posterior pair of lateral fins. In the



outer portion of each ovary is a dense granular tract (fig. 6, *a*), the remainder of the cavity being occupied by a more finely granular stroma in which the ova are developed, attached at first by short pedicles to the placental tract. In the outer portion of this tract runs a slender cæcal canal, which may be traced close to the opening of the oviduct (fig. 6, *b*). This canal, which was first noticed by Wilms (l. c. p. 13, fig. 10), is regarded by Krohn (Wieg. Archiv. 1853, p. 269), as a *receptaculum seminis*, seeing that it is occasionally found to be filled with actively-moving spermatozoa. According to Wilms and Huxley, the canal is lined with cilia, but Krohn is of opinion that this appearance of cilia is due to the presence of the motile spermatozooids. The ova (fig. 6, *c*) present no peculiarity, except that Wilms and Krohn concur in stating that a germinal spot is never observed in the comparatively large germinal vesicle.

2. *The male apparatus.*—The caudal portion of the animal (fig. 1, *d*) is divided by a vertic 1, longitudinal septum, into two perfectly distinct compartments. These compartments may properly be termed the *testes*, as it is in them that the development of the spermatozoa appears to take place, which is thus described by Wilms (l. c. p. 13). In younger individuals, each compartment contains a greater or less number of vesicles of various dimensions, some spherical, others of irregular form, elongated, and ovoid. At first sight they seem to be filled with a sort of granular substance, but when a little larger, are plainly seen to contain minute spherical cells. In animals nearer maturity, besides these cysts, there will also be noticed cells in which, upon the addition of acetic acid, a nucleus is plainly visible. From these aggregations of cells (fig. 9), which are always somewhat less in size than the cysts above noticed, the spermatozoa are developed. At a certain period, slender filaments are seen to proceed from them, causing the appearance as if the cells were beset with spines, whilst others present the appearances represented in fig. 12, *a, b*, indicating a further stage of development. The central cellular mass (shown at *a*, fig. 12) gradually diminishes in bulk as the filamentary portions become more and more developed (fig. 12 *b*), and gradually disappears altogether, nothing remaining but bundles of spermatozooids attached to each by their heads. These bundles eventually break up into separate spermatozooids. The mature spermatozoid is a long filament, slightly enlarged at one extremity, beyond which, however, the point is usually prolonged in the form of a very delicate short thread (fig. 11).

A remarkable circumstance observable in the spermatic cavities of *Sagitta*, is the continual cyclosis performed by their

contents.\* These will be seen constantly ascending on the outer, and descending on the internal wall or septum in the directions indicated by the arrows in fig. 4. The cause of this motion is stated by Krohn to depend upon the presence of scattered cilia in the posterior part of the cavity.

The spermatozooids thus formed make their exit from the cavity in a very curious mode. On each side of the caudal portion will be observed a projection, (figs. 1 and 4, *e e*), which may, perhaps, be regarded as a sort of ejaculatory apparatus. These processes are hollow sacculi, which open externally by a rounded orifice situated at the upper end, and communicate with the interior of the compartment to which they belong, through a canal excavated in the integuments of the caudal portion. If, as Krohn observes, one of the seminal compartments be laid open by a longitudinal incision on the under surface, and the contents carefully removed, an opening surrounded by a raised margin will be clearly seen at a short distance from each ejaculatory sac. This orifice leads into the canal above mentioned, which runs along the corresponding border of the upper muscular band, making a slight curve posteriorly, gradually contracting in size, and finally opening in the cavity of the ejaculatory sac. The inner wall of these efferent canals, as well as of the external sac, is lined with an actively vibrating ciliated membrane.

With respect to the mode in which the spermatozooids come in contact with the ova nothing is known, though it would seem, if Krohn's observation above related, of the presence of spermatozoa in the caecal canal contained in the ovary be confirmed, that they must make their entrance in some way into that organ. It is more probable, however, that the ova are impregnated after extrusion; and that this is the case, is rendered the more likely by the circumstance that innumerable spermatozooids in the most active motion may occasionally be observed, swarming out of the orifice of what I have termed the ejaculatory sac (fig. 5). And it seems scarcely possible that these motile filaments should make their way spontaneously into the narrow and close opening of the oviduct, which they must do in order to reach the canal in question.

The *Sagitta* is obviously oviparous; but with respect to the further development of the ova after deposition, little is known. According to Krohn (Wieg. Arch. 1853, p. 270), the vitellus consists of numerous cells containing an albuminous fluid, and in which he was unable to perceive any vitelline granules. It is surrounded by two membranes. The internal, which

\* Krohn remarks (p. 13), that a similar movement of the spermatic globules is observed in the testicular vesicles of the Leech.

closely envelopes the vitellus, is thin and firm; the proper vitelline membrane, whilst the outer is much thicker, and according to him of a gelatinous consistence, swelling up rapidly when the ova escape into the surrounding water. At a later period it is sometimes absent, although the development is not, according to Krohn, by this interfered with. Mr. Darwin also (l. c.) assigns an outer envelope to the ovum, but it would seem that this envelope was of a firmer consistence than the one described by Krohn, since he states that it is ruptured soon after the commencement of partial segmentation of the vitellus, which undergoes its further development after it has thus escaped.\*

Many species of *Sagitta* are described by different authors, but it would seem that considerable confusion still exists on this subject. One thing appears tolerably certain, viz., that the species common on the British coast, and which is the one here described, is, as before stated, very widely distributed in all seas from the north to south antarctic oceans. And it may well be supposed that superficial observation of specimens at different ages and of different sizes, may have caused an unnecessary multiplication of species.

Krohn, who considers that the number, position, and form

\* In Siebold and Kölliker's 'Zeitschrift f. Wissens. Zoologie,' Bd. v., p. 15, is a short notice respecting the development of *Sagitta*, by C. Gegenbaur. He states, that the process of segmentation terminates in the production of an embryo of a rounded form, in which two kinds of cell-masses may be recognized,—one central, constituted of minute, and a well-defined peripheral layer, composed of larger cells. A depression is now formed at one point of the surface, which gradually advances to the centre, constituting the rudiment of the intestine. The embryo now appears to increase in length, in consequence of which, since it completely fills the cavity of the *ovum*, it becomes bent, and is ultimately coiled in a vermiform fashion. The cavity of the trunk may be distinguished, traversed by the intestine, which forms, as it were, a vertical septum; but, besides this, no other internal organs are apparent. At this period the embryo often moves, and on the addition of acetic acid the muscular bands in the trunk are visible, completely formed, and exhibiting the fine transverse *striae*. The fins arise as simple lateral outgrowths of the body. In this condition the animal leaves the *ovum*, about  $\frac{1}{4}$ " in length, and already presenting in all respects the character of the full-grown *Sagitta*. The other organs, consequently, are not developed until after the animal has quitted the *ovum*. In the entire course of development, many stages of which, particularly those which succeed complete segmentation, are very difficult to be understood, *cilia* never make their appearance.

If the anatomy of this creature had not satisfactorily shown that it belongs neither to the Pteropoda, nor to the Heteropoda—this would have been rendered certain by its mode of development, which does not accord in any respect with the Molluscan type. What the real position of *Sagitta* is I will not determine.

of the lateral fins will afford most useful diagnostic characters, describes the following species:—

1. *S. multidentata* (Wieg. Arch. 1853, p. 271, Plate 12, fig. 2).—Which in habit closely approaches the *S. setosa* of Wilms (our *S. bipunctata*). The posterior fins are longer and wider than the anterior, which extend in front to about the anterior third of the body. The number of hooks is from 9 to 11. That of the denticles in front of the mouth (fig. 3, a), is in the anterior row from 5 to 8, and in the posterior from 12 to 13.

He notices another form closely resembling the above, but characterized by the existence of a horny, toothed ring around the orifice of the ejaculatory sacs.

2. *S. serrato-dentata* (l. c. figs. 3 and 4).—Which appears to resemble the foregoing in nearly all respects, except in the conformation of the hooks, which are described as serrated on the inner edge for about half their length. The number of hooks is from 6 to 8 on either side. The denticles in the anterior row are never more than eight in number on each side, whilst in the posterior there are as many as 18. The bundles of rigid *setæ* are disposed symmetrically in eight lateral rows, four dorsal and four on the ventral aspect. It is a very small species, not exceeding  $4\frac{1}{2}$  m. in length.

3. *S. lyra* (l. c., fig. 5).—The caudal portion of the body very short and separated by a groove from the elongated trunk. The two pairs of lateral fins are apparently continuous with each other, and the anterior are much longer than the posterior, and extend far anteriorly. The number of hooks is 6 to 8 on either side; of the denticles, 7 in the anterior and 11 in the posterior series. The bundles of *setæ* are irregularly distributed over the surface of the body. It is a large species, attaining the considerable length of from 3 to  $3\frac{1}{4}$  centim.

4. *S. draco* (l. c., fig. 6).—The body of this rare form is short and thick, and invested for the anterior three-fourths of its length, by a very considerable layer of large, thick-walled cells. The caudal portion is very long, the trunk short, and the caudal fin of large size. The anterior pair of lateral fins is wholly wanting, and the pair corresponding to the posterior fins of other species do not extend beyond the caudal portion of the body. The species is remarkable also for the existence of two lateral and opposite bundles of numerous, very long, freely-floating filaments, seated upon special eminences, which again are placed upon the cellular layer surrounding the anterior part of the body. The filaments are of soft consistence, ligulate, and constituted of parallel longitudinal fibrillæ. There are ten hooks on either side; eight

anterior denticles on each side and 18 posterior. The bundles of rigid *setæ* are scattered irregularly over the surface. The only individual met with by Krohn was one centimetre in length.

Other species described by authors are—

5. *S. cephaloptera* (Busch, l. c., pl. xv., fig. 2).—Distinguished by a radiated disc on the anterior part of the trunk, and two tentacular processes on the sides of the head.

6. *S. rostrata* (Busch, l. c., fig. 7).—Distinguished from *S. setosa*, Wilms, by the presence of a large rounded eminence on the anterior part of the head, which Krohn imagines may be caused in a young specimen of a *Sagitta* by the cephalic ganglion.

7. *S. bipunctata*, Quoy and Gaimard, which we regard as identical with—

8. *S. setosa*, Wilms, the species here described, and probably the parent of other species, among which perhaps may be enumerated those named by D'Orbigny (*Voyage dans l'Amerique Meridionale*, tom v., p. 14, Pl. 10) according to the number of their fins, as *S. diptera*, *S. triptera*, and *S. hexaptera*. If all these really belong to *Sagitta* at all, which, in the absence of farther information than that given by D'Orbigny, may be regarded as doubtful, *S. hexaptera*, at any rate, may be considered identical with *S. bipunctata*.

With respect to the systematic position of *Sagitta*, very considerable difficulties arise in the determination of it. Mr. Huxley (l. c., p. 77) remarks that "*Sagitta* has been placed by some among the Mollusca, a view based upon certain apparent resemblances with the Heteropoda. These, however, are superficial; the buccal armature of *Sagitta*, for instance, is a widely-different structure from the tongue of *Firola* to which, when extended, it may have a distant resemblance." "There appears," he says, "much more reason for placing this creature, as Krohn, Grube, and others have done, upon the annulose side of the animal kingdom; but it is very difficult to say in what division of that sub-kingdom it may most naturally be arranged." After surveying the points of resemblance and difference between *Sagitta* and the nematoid worms and certain Naiadæ, Mr. Huxley concludes by observing "that the study of its development can alone decide to which division of the annulose sub-kingdom *Sagitta* belongs; but that until such study shall have demonstrated the contrary, he stated his belief that *Sagitta* bears the same relation to the Tardigrada and Acaridæ that *Linguatula* (as has been shown by Van Beneden) bears to the genus *Anchorella*, and that the

young *Sagitta* will, therefore, very possibly be found to resemble one of the Tardigrada, the rudimentary feet with their hooks being subsequently thrown up to the region of the head as they are in *Linguatula*."

Krohn, with much hesitation, is inclined to regard it as belonging to the Annelid group, with which it would certainly at present appear to exhibit a very probable relationship.

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*On the MAGNIFYING POWER of SHORT SPACES illustrated by the TRANSMISSION of LIGHT through MINUTE APERTURES.*  
By JOHN GORHAM, M.R.C.S.E., &c.

HAVING described in the former papers the appearances observable when pencils of light from small circular apertures are partially intercepted by certain opaque or transparent objects of definite shape and size; and having shown that whether shadows or illuminated spaces are thus used, they serve to exemplify the magnifying power of short intervals existing between the organ of vision and the object to be examined, inasmuch as they occupy some *position in space*, and have a certain *form*, qualities which pertain to them in common with all substances appreciable by the sense of sight, we proceed to notice the phenomena which result when exceedingly narrow linear apertures are substituted for those of a circular form. In conducting these investigations it was not unreasonable to suppose, à priori, that if the size, the quality, and the position of the object to be examined, the direction and the intensity of the light which was used, the sensitiveness and immediate response of the pupil of the eye to the minutest variation in the quantity of light impinging on the retina, and the refracting qualities of the transparent portion of the visual organ, were each and all taken into account, so that a nice and delicate adjustment of the eye to the light, and of the light as well as of the size of the objects to the eye could be insured, appearances perhaps beautiful, doubtless uncommon, and certainly interesting to the physiologist might be fairly anticipated. Such anticipations, have been so far realized as to present a strong inducement to prosecute the subject with a legitimate prospect of still greater success.

It is obvious that the phenomena which have occupied our attention are chiefly due to the formation of shadows. For when a divergent pencil of light proceeding from a small circular perforation in a card falls upon the eye, and when a small object either transparent or opaque—a transparent cross on a black ground, or a black cross on a transparent ground,