The Nematocysts of Turbellaria.

By

C. H. Martin, B.A.,
Magdalen College, Oxford.

With Plate 14.

Prior to 1903 it was accepted by most zoologists that nematocysts were formed in three separate phyla of the animal kingdom—in Cœlenterates, Turbellaria and Mollusca.

If it were really the case that the nematocysts which undoubtedly occur in these three separate phyla are produced by the tissues of the creatures containing them, it would be an example of convergence without parallel in the animal kingdom.

For both in Æolids and Turbellaria there are instances of individual species containing nematocysts of two or three different kinds which are the exact duplicate of similar structures in the Cœlenterates.

In all other cases of convergence, though there may be a strong superficial resemblance in structures occurring in animals widely separate from one another, careful analysis shows that the resemblance never amounts to identity, as it does in this case.

As long ago as 1858 Strethill Wright explained the presence of nematocysts in Æolids on the hypothesis that they are derived from the Hydroids on which they feed, and in 1903 Grosvenor (**8**), after a searching investigation, raised this hypothesis to the level of an established fact.

Since it has been proved that the nematocysts of Æolids

are extraneous structures it seemed to me that the same would probably prove to be the case in Turbellaria, and the following paper is an account of the investigation which I have made on the subject.

The research was commenced in Scotland on Loch Tay and Loch Lomond, when I was working on the Scotch Lake Survey under Sir John Murray, to whom, for his kindness, I am greatly indebted.

In November, 1906, I had the opportunity of occupying the Oxford Table at the Naples Aquarium, and there I was enabled to examine some of the Marine Turbellaria, in which the presence of nematocysts has been suspected.

I should like to take this opportunity of thanking the staff of the Aquarium, and Professor Dohrn in particular, for the great kindness they showed me.

In April I had an opportunity of showing some preparations to Professor von Graff, and discussing the question with him.

Finally, I should also like to thank Professor Bourne for his great help in the preparation of the paper.

The nematocysts of Turbellaria were probably first observed by Oersted (**13**) in Microstoma lineare but he failed to recognise their true character, and described them as "Krugformige Drusen." They were subsequently examined by von Siebold (**17**) in 1848, and he leaves no doubt as to his recognition of their nature describing them as thread cells which "denen der Hydra auf ein Haar gleichen sollten."

Hallez (**9**) described the thread of the nematocysts in Microstoma lineare as "liquide qui se coagule légèrement au contact de l'eau," and put forward in common with M. Müller and Leuckart, the view that rhabdites were degenerate nematocysts. The essential difference between these two structures lies, of course, in the fact that whilst the rhabdite is a solid rod of more or less homogeneous nature, the nematocyst is a capsule containing a spirally rolled thread which can be everted under suitable conditions.

Von Graff (5), in his great work on Turbellaria in 1882, stated that the nematocysts of Microstoma can be distinguished from those of Hydra (1) by their smaller size, the length of the large capsule measuring 0·015 mm., and the thread 0·26—0·13 mm.; (2) by the presence of only four barbs. He contradicts Hallez, who had correctly described the nematocysts as lying in vacuoles, asserting that each lies in a single cell which (although on this point he seems to have been somewhat doubtful) possesses a cnidocil. He also described so-called intermediate forms between rhabdites and nematocysts in Polycystis (Macrorhyncus), Mamertinus, etc., and concluded that nematocysts were homologous with rhabdites ("so scheint die auch von Hallez acceptierte Homologie zwischen den Rhabditen und Nematocysten der Turbellarien ziemlich sicher begrundet, und wir konnen mit M. Müller und Leuckart die ersteren als niedere Zustande von Nesselorgane beobachten").

Fuhrmann (4) has more recently studied the large oval nematocyst in Microstoma. He finds that they measure ·0084—·0187 mm. in length, and that the distal end is closed by a lid, which springs off when the nematocysts explode.

The thread, according to his account, is solid, measuring about ·137 mm., and there are four long and four short barbs. Under these circumstances it would seem very difficult to understand how, with a solid thread, the explosion is effected, since his drawings show that the barbed base of the thread is everted.

In his latest work on Turbellaria in Bronn's 'Thierreich,' von Graff (7) places all the rhabdite-like structures—rhabdoids, pseudorhabdites, sagittocysts, and nematocysts—under a common category of Hyaloids.

(*a*) The rhabdoids measure from 0·16 μ to 87 μ, and are sub-divided into rhamnites (bent rods) and rhabdites, which are more resistent, cylindrical, or elliptical bodies. They may be formed either in the mesenchyme or in the epithelial cells.

(*b*) Pseudorhabdites are usually confined to the Alloiocœla, and are characterised by their granular appearance.

(*c*) Sagittocysts are confined to the Acœla, and consist of a membrane surrounding a cavity in which a solid needle-shaped body lies.

They seem to occur only in the genital regions at the period at which the male sexual products are mature, and are regarded as "Reizmittelm bei der Begattung."

(*d*) Nematocysts.

Von Graff summarises his views as to the connection between these various structures in the following passage:

"Von den als Ausganspunkt erscheinendem Pseudo-rhabditen, welche sich weder gegen das ungeformte Secret der Hautdrüsen einer noch gegen die strukturlosen Rhabditen andererseits scharf abgrenzen lassen, führt auf diese Weise, durch solche Rhabdoiden bei welchen sich ein hyalinen Mantel von der Kornigen Zentralmasse scheidet (Rhammiten) die schrittweise Differenzierung zu Sagittocysten und den verschiedenen formen von Nematocysten—Eine Anschauung die ich schon 1874 ausgesprochen habe."

The following list contains, I believe, the names of all the Turbellaria which have been described as possessing nematocysts. These which I have been able to examine are marked with an asterisk:

RHABDOCŒLA.

Section 1.—HYSTEROPHORA.

Fam. CATENULIDÆ.

Microstoma lineare.*
„ giganteum.*
„ rubromaculatum.*
„ papillosum.*
Stenostoma sieboldii.*

Section 2.—LECITHOPHORA.

Sub-section: KALYPTORHYNCHIA.

Fam. POLYCYSTIDIDÆ.

Polycystis naegelii.*
„ mamertinus.*

POLYCLADA.

Hyporhyncus armatus.
Anonymus virilis.
Stylochoplana tarda.

ALLOIOCŒLA.

Allostoma monotrochum.
Plessisia setosa.

Of all the Turbellaria, as far as I can discover—Microstoma lineare, Stenostoma sieboldii, Plessissia setosa, and Stylochoplana tarda are the only forms in which the actual expulsion of a thread from the nematocyst has been described.

In most of the other species of Rhabdocœls the so-called nematocysts are bodies of very small size in which the appearance of a coiled thread has been suspected.

The two Polyclads in which nematocysts have been described are unfortunately very rare Stylochoplana tarda and Anonymus virilis having only once been found.

Microstoma lineare.—In Microstoma lineare nematocysts are by means of universal occurrence. Du Plessis (**16**) described a variety from the deeper water of Lake Geneva in which nematocysts were absent. This form has more recently been raised to specific rank by Zacharias (**20**) under the name of Microstoma inermis.

I have twice found a similar form in Loch Tay at a depth of about 200 feet. It is characterised by the absence of eyes and nematocysts, but as nearly all littoral Rhabdocœls lose their eyes in deep water, and as I hope to show that the absence of nematocysts is merely the result of the absence of Hydra at this depth, I do not think the species can be maintained.

In those animals in which they occur nematocysts vary enormously in number, and it is fairly evident that they are most numerous in the forms from Scotch lochs in those individuals caught on stones on which Hydra rubra is very abundant.

In the living Microstoma the nematocysts may be seen to lie in vacuoles just under the skin. They may lie singly or to the number of three or four together; very frequently the same vacuole encloses nematocysts of different types. I have seen cases in which a vacuole enclosed one large barbed nematocyst with three small oval nematocysts, and in other cases I have seen the barbed form accompanied by the cylindrical form.

In Microstoma lineare from Loch Tay and Loch Lomond I have found three kinds of Nematocysts, which cannot be distinguished from the nematocysts of Hydra rubra occurring in the same regions. (*a*) The large barbed nematocysts measure, in an unexploded condition in balsam preparations, 12—15 μ length, 7—9 μ breadth, and when the nematocyst is discharged the length of the thread is about 400 μ. There are only three large barbs directed backwards at the end of the thickest portion of the thread. (*b*) The small cylindrical nematocysts measure in length 12 μ, in breadth 4 μ, and the length of the thread is about 300 μ. (*c*) There are also small spherical nematocysts with a thick thread and no barbs. In sections through a Microstoma nematocysts may be found lying in four different positions—(1) in the lumen of the gut, (2) in the cells of the gut, (3) surrounded by cells in the body cavity between the gut wall and the ectoderm, (4) in the ectoderm.

(1) In the gut of a Microstoma which has recently eaten a Hydra, the nematocysts may still be found lying in the tissue of the Hydra in the lumen of the gut.

(2) As digestion proceeds, the nematocysts are engulfed by the cells of the gut, and may be found lying to the number of two or three in the same cell.

(3) At a later period nematocysts can be found lying just outside the gut, sometimes free, but usually surrounded by three or four small cells. These cells seem to be mesenchymatous phagocytes, though I am not quite sure whether it is not possible for the cells of the gut itself to become free and

take up a wandering existence in the body cavity. Finally the nematocyst is transported to a position directly under the ectoderm ; here it lies in the vacuole (vide. figs. 2—4) (which is not an artifact, since it can be seen in the living animal) surrounded by about six cells. The wall of the vacuole after a time becomes thinner and denser. There is one point of great interest as regards the orientation of the nematocysts under the skin. The large barbed nematocysts in their final position, always lie so that the thread, when it is discharged, will pass out of the animal, although they may lie pointing in any direction while they are still in the gut cells or the body cavity. This rule does not seem to hold good in the small cylindrical nematocysts, which, as far as I can see usually lie almost parallel to the surface. It is very difficult to say how such an orientation can be effected, but something of the same kind has been detected in Æolids, and I believe that the same difficulty is present in the nematocysts of the tentacles in Cœlenterates. In Hydra the tentacles are crowded with ripe nematocysts, but the chief region in which young nematoblasts are to be found is the distal region of the body below the level of the tentacles.

As regards the mode of infection it was rather difficult à priori to see how such a small animal as Microstoma could devour a Hydra ; but it must be remembered that Hydra is generally observed in an extended condition, whereas Microstoma, except immediately after a meal, is never seen extended to its full size. Even the small Microstoma will readily swallow a fairly large Cyclops or Lycnæid, and these are more awkward animals to digest than a contracted Hydra rubra. If a fasting Microstoma is placed in a watch-glass which contains some small Hydra, it is almost certain in a short time to come into contact with one of them. If the Microstoma comes suddenly against the tentacles of the Hydra it contracts itself immediately, and in this condition it may frequently be killed by the discharged nematocysts. As a rule, however, the Microstoma fixes itself for a short time by its

posterior end in the neighbourhood of the Hydra, and everts its pharynx to its full extent.

The Microstoma then swims over the surface of the Hydra, usually attacking the lower part of its body with its pharynx fully everted (vide fig. 10). The Hydra then usually becomes strongly contracted, and sweeps its tentacles over to the side on which it has been attacked, though under these conditions the tentacles do not grasp the Microstoma, but remain extended almost parallel with its body, and it would appear as though the pharyngeal secretion had a paralysing action on the Hydra. In many cases, after a time, the Microstoma leaves its prey, and in such a case the Hydra does not seem much the worse for the attack, but if the Hydra is of small size, it may be engulfed, and swallowed whole.

To further examine the effect of this pharyngeal secretion I placed some Hydra, which had been kept living in a solution of neutralroth, in a watch-glass with a Microstoma, and it could then be seen that the vacuoles of the ectoderm of the Hydra, which had been stained a pink colour by the neutralroth, took a yellowish-brown colour under the action of the digestive fluid, indicating that the secretion was probably of an alkaline nature, and possibly allied to trypsine. If a Microstoma which contains nematocysts is placed in a watch-glass, and a dilute acid or alkaline added, the nematocysts under the skin are discharged. It would be very interesting to determine how far the Microstoma is capable of using its nematocysts for purposes of attack or defence.

One of the common enemies of Microstoma appears to be Chætogaster, which devours it greedily. One evening I placed six large Microstoma in a watch-glass with two Chætogaster, and by 10 a.m. next morning all had been eaten. In one case which I examined I found a Chætogaster, some time after it had swallowed three Microstoma, had eight large exploded nematocysts in its gut, but the presence of nematocysts in its prey seems to have no deterrent effect upon the Chætogaster.

As regards the mechanism by which this discharge is

effected I think that any muscular or nervous influence in the case of the nematocysts of Microstoma is excluded, and I have never found any trace of a cnidocil-like structure. I am inclined to agree with Grosvenor that the discharge of a ripe nematocyst is only effected when it is brought into a solution of less osmotic pressure. At the time when the nematocysts of the Hydra are ingested by the Microstoma, they lie in a mixture consisting of the pharyngeal secretion of the Microstoma and the partly digested ectoderm cells of the Hydra. When the Microstoma is irritated by acetic acid or an alkaline solution, the ectoderm probably becomes slightly contracted, and the end of the nematocyst is forced between the ectoderm cells, water is taken up, and an explosion follows.

In order to establish a definite proof that the nematocysts of a Microstoma proceed from its prey, there seem to be only three courses open :

(1) To feed the Microstoma upon Hydra in which the nematocysts have been stained *intra vitam* with some dye, and follow the passage of the coloured nematocysts through the gut under the ectoderm of the Microstoma.

(2) To feed the Microstoma upon some other Cœlenterate which has nematocysts of a different shape to those of Hydra.

(3) To rear Microstoma from the egg without feeding it on Hydra.

In the first case I kept some Hydra in water containing methylene blue, and found that some nematocysts, usually those that were not fully developed, took up the stain with great intensity. I fed some Microstoma on these Hydra, and a Microstoma which was placed with these Hydra at 1 o'clock had a mass of blue in its gut at 5 o'clock. Next day in most cases the colour had faded, and in only one case did I see blue nematocysts actually under the skin. This specimen was mounted, but unfortunately the colour has since, to a large extent, faded.

With regard to the second course, this is the method that has been used with such success by Strethill Wright,

Grosvenor, and Cuénot in their proof that the nematocysts of Æolids were derived from their prey.

This summer I found Microstoma in Hickling Broad in Norfolk. In this Broad, Hydra seems to be fairly rare, but Cordylophora lacustris is very abundant.

Most of the Microstoma I found were absolutely free from nematocysts, but some contained the nematocysts of Cordylophora in the ordinary vacuoles under the skin. Cordylophora contains nematocysts of two kinds.

(1) Oval Barbed Nematocysts.—These are of a very characteristic shape. They are more or less egg-shaped structures with one pole smaller than the other, and in profile the one side is slightly convex whilst the other is concave. In the exploded condition the thread passes from the small pole, the swollen base of the thread is rather long and set with numerous barbs which decrease slightly in length in the distal portion.

(2) The Small Oval Nematocysts are rather like the small oval nematocysts of Hydra, and are provided with a short thick thread free from barbs.

I placed a Microstoma, from Hickling, in which I had not been able to find nematocysts, in a watch-glass with some teased-up Cordylophora, and twenty-four hours afterwards I fixed and cut sections of it. The gut still contained portions of disintegrating Cordylophora, but nematocysts were found under the skin, both in the exploded and the unexploded condition.

By feeding a Microstome with Cordylophora which had previously been fed upon Hydra I succeeded in obtaining a mixed infection, the animal having both Cordylophora and Hydra nematocysts under the skin.

Third Course.—This would seem at first sight the most ready method of settling the question, but there are two very great difficulties. During the greater part of the year Microstoma reproduces entirely by budding, and it is only in September in Scotland that I have been able to find sexual individuals.

I have only once found ripe female Microstoma in Loch Lomond towards the middle of September, but the material which I then obtained was unfortunately lost. Even if, however, this difficulty is overcome, I do not believe that trustworthy results can be obtained by this method.

I have found very young Microstoma in which nematocysts were already present, and at first this presented a difficulty to this theory of the derivation of nematocysts, but I do not believe this is insuperable when we consider that nematocyst in the case of an animal which has fed largely on Hydra can be found in almost any tissue of the body. I have found them in the testes (fig. 8), and although I have not yet found them in an ovum, I believe that the yolk-cells might readily carry the nematocysts into the cocoon thus causing the infection of the young forms.

Microstoma giganteum.—This form was described by Hallez, and according to von Graff, the only details given as to the nematocysts are that they are larger and more numerous.

Microstoma rubromaculatum.—This form has only twice been found by von Graff in the Bay of Naples. In his description he says, "Stäbchen fehlen; der Haut dagegen enthält dieselbe Gruppen minutiöser ovaler, starklichtbrechender Körperchen von 0·003 mm. Breite und 0·007 Länge (fig. 16), die ich nach ihrer Ansicht von oben (*a*) und von der Seite (*b*), für Nesselkapseln mit eingeschlossenen kurzen Faden halten muss."

I found this form on one occasion at Naples on some weed from the Mergellina. In the form which I examined there were large cells scattered in the epidermis containing minute rods which stain very readily with eosin. There were also a few small oval nematocysts.

Microstoma papillosum, von Graff.—A single example of this form was found by Claparède at Sarteroe, on the coast of Norway, and figured by him as a Dendrocœl larva. The animal measured ·3 mm. long, and he says nothing of nematocysts, though he figures the long rhabdites. In the

'Zoologischer Anzeiger,' in 1889, Böhmig describes an undoubted Rhabdocœl which he found at Trieste, and which he identifies with Microstoma papillosum. The size of the chains measures 500 μ to 1100 μ. There were no eyes, but adhesive papillæ were present. Nematocysts which he does not figure, were found. From the form of the animal, the appearance of the rhabdites, and the presence of the papillæ, one would feel that it must resemble extremely closely Stenostoma sieboldii.

Stenostoma sieboldii.—Von Graff figures a specimen in which there were present—

(1) Bundles of large rhabdites,

(2) Small oval nematocysts.

It is interesting to observe that the nematocysts lie to the number of 2—5 in common vacuoles under the skin (and apparently in the gut). In the forms which I examined I could not find the small nematocysts, but I was able, by feeding Stenostoma on chopped Eudendrium, to get specimens in which unexploded nematocysts lay in the gut and under the skin.

Kalyptorhynca.

Von Graff, in his Monograph of the Turbellaria, remarks: "In die Kategorie der Nematocysten gehören schliesslich die am Rüssel gewisser Prosbosciden die Stelle der Rhabdites vertretenden Gebilde." He then states that the epithelium of the proboscis in Polycystis mamertinus and nægellei contains almost identical "eiformige gebilde," which he considers to be nematocysts, and which he believes show their homology with true rhabdites through the presence of intermediate forms.

Von Graff was unable to detect the expulsion of a thread in these structures, and I believe that they can only be regarded as rhabdites resembling those on the rest of the body. In sections stained with methyl-blue-eosin these structures on the proboscis and the rhabdites of the skin take up a similar bright red colour (figs. 13 and 14).

As regards the function of the proboscis in these forms there seem to be two divergent views: (1) Hallez regards the proboscis mainly as an organ of prehension for seizing the animal's prey, and in his account of Gyrator notops the following passage occurs: "Si l'on place sur le porte-objet d'un microscope quelques Gyrator, avec des Cyclops, on ne tarde pas à voir, a la première rencontre, le Gyrator devaginer sa trompe et fixer lentement sur sa victime l'epithelium adhésif de son organe de préhension." Hallez describes rhabdite-like structures in the proboscis, to which he is inclined to attribute an adhesive function. (2) This view is strenuously denied by von Graff in his monograph. He asserts that the proboscis functions only as a tactile organ. If we regard the proboscis as a purely tactile organ it is very hard to explain its enormous muscular development in such forms as Polycystis goettii, nægelii, Gyrator, etc. The base of the proboscis consists of an enormous mass of muscle to which are attached long powerful retractor muscles. I have myself seen both Polycystis goettii and Polycystis nægelii capture Copepods with their proboscis. In one case in which a Polycystis nægelii had captured a large Copepod in this manner, it bent round and started swallowing the posterior thoracic feet, which seemed paralysed, although the violent movements of the gut and the anterior appendages showed that the animal was still alive.

Alloiocœla.

Allostoma monotrochum.—As far as I know only three specimens of this form have been found by von Graff, in 1879, in Trieste. He describes it as possessing oval bodies in the skin from 0·003—0·004 mm. long, with the appearance of a coiled spiral thread which, however, he never saw ejected.

Polyclads.

I have not been able to examine any of the Polyclads which have been described as possessing nematocysts, as they are unfortunately extremely rare.

Anonymus virilis has only twice been found by Lang in the Bay of Naples. The nematocysts are described as oval structures. They are formed in the parenchyme and pass along specialised tracts to the surface. They have never been seen discharged.

Stylochoplana tarda.—This form, as far as I know, has only once been found by von Graff at Trieste. It is interesting to observe that it only differs from Stylochoplana fusca by its slightly smaller size, sluggish habits, and the possession of nematocysts. The nematocysts have not been figured, but they are said to be over the structures ·01 mm. long with a thread ·015 mm. long, and a base covered with spiral rows of short spines ·009 mm. long. In this case it is very tempting to suppose that the nematocysts, which are of a very common Cœlenterate type, were ingested with the food, and that this species is really identical with Stylochoplana fusca.

Conclusions.

There are only three possible views as regards the presence of nematocyts in Turbellaria :

(1) It might be said that they are absolutely homologous structures with the nematocysts of the Cœlenterates, and to be an indication of the very close relationship between these groups (a theory that is put forward in a recent text-book). There are, however, several difficulties to the acceptance of this view. In the first place no one has yet been able to trace the development of a nematocyst in a Turbellarian nematoblast. And secondly, it would be very difficult to show Cordylophoran affinities in the Microstoma from Hickling as compared with the Hydroid affinities of those of the neighbouring Sutton Broad.

(2) The presence of nematocysts might be regarded as a case of convergence, and if this theory were accepted it must be generally admitted that we have here the most remarkable and repeated examples of convergence in the animal kingdom. In this case again the experimental evidence, in which it is shown that Microstoma changes its type of nematocyst with its change of food is fatal.

(3) The one remaining possibility is the transference of the nematocysts of a Cœlenterate to the animal which preys upon it. The theory which was first established by Strethill Wright for Æolids. It is clear from what has been written above that this last view must be accepted. Since it has been shown that—

(*a*) The nematocysts of Microstoma lineare are normally derived from the Hydra upon which it feeds.

(*b*) If the Microstoma is fed upon Cordylophora, Cordylophora nematocysts are found under the skin.

(*c*) The nematocysts of Stenostoma sieboldii are derived from the Cœlenterata on which it feeds.

The same process probably occurs in the other Turbellaria with the possible exception of Anonymus virilis, and therefore the presence of three nematocysts in a Turbellarian offers no ground for the generally accepted homology between Nematocysts and Rhabdites.

Literature.

1. Bédot.—"Note sur les cellules urticantes," 'Rev. Suisse Zool.,' vol. iii, 1895.

2. Böhmig.—"Microstoma papillosum," 'Zool. Anzeig.,' vol. xii, 1889.

3. Claparède.—'Récherches Anatomiques . . . dans les Hebridés,' 1861.

4. Fuhrmann.—"Die Turbellarien der Umgebung von Basel," 'Rev. Suisse de Zool.,' tome ii, 1894.

5. Graff.—'Monographie der Turbellarien,' 1882.

6. ——— "Stenostoma sieboldii," "Stylochoplana tarda," } 'Zeit. wiss. Zool.,' xxx, Leipzig, 1882.

7. Graff.—"Turbellarien," 'Bronn's Thierreich.'

8. Grosvenor.—"Nematocysts of Æolids," 'Proc. Roy. Soc.,' lxxi, 1903.

9. Hallez.—'Contributions à l'Histoire naturelle des Turbellariés,' Lille. 1879.

10. ——— 'Zoologie Descriptive,' Paris, 1900.

11. Iwanzoff.—"Ueber die Wirkungsweise und die Entwicklung nesselkapseln von Coelenteraten," 'Bull. Soc. Imp. Nat. Moskow,' 1896.

12. Lang.—'Monograph der Polycladen,' Naples.

13. Oersted.—'Plattwurmen,' Copenhagen, 1844.

14. Landenfeld.—"Nesselzellen der Coridaiien," 'Biol. Centralblatt,' 1897.

15. Pénard.—"Le Mécanisme de la detente dans les cellules urticantes," 'Arch. Soc. Phys. et Nat.,' xxix, Geneva, 1893.

16. du Plessis, G.—'Rev. Suisse Zool.,' v, 1897.

17. Siebold, von.—'Lehrbuch der Vergleichenden Anatomie,' 1848.

18. Silliman.—"Beobachtungen über die Susswasser Turbellarien Nord Ameriken," 'Zeit. f. wiss. Zool.,' xli, 1888.

19. Strethill Wright.—(*a*) 'Proc. Roy. Phys. Soc.,' vol. i, p. 206, 1856; (*b*) 'Q. J. M. S.,' vol. iii, p. 52, 1863.

20. Zacharias.—"Faunistische Mittheilungen," 'Biol. Stat. Plön.,' 1894.

EXPLANATION OF PLATE 14,

Illustrating Mr. C. H. Martin's paper on "The Nematocysts of Turbellaria."

Fig. 1.—An oval barbed nematocyst with two small oval nematocysts lying in a common vacuole under the skin of a living Microstoma lineare. Zeiss apoc. 2 mm. + 6 comp. oc.

Fig. 2.—Small oval nematocyst from a living Microstome. Outline same magnification as Fig. 1.

Fig. 3.—Cylindrical nematocyst in vacuole in skin of Microstoma lineare.

Fig. 4.—Part of a transverse section through Microstoma lineare fed on Hydra rubra.

a. Oval barbed nematocyst in gut cell.

b. Under the skin.

c. A cell from the wall of the vacuole lying above the nematocyst.

Fig. 5.—Part of a transverse section through Microstoma lineare, showing nematocysts, some of which lie in vacuoles in the cells of the gut, while others have been carried through into the body cavity. *Ep.* Epidermis. *B.C.* Body cavity.

Fig. 6.—Nematocyst surrounded by Phagocytes lying in the body cavity. Transverse section of Microstoma.

Fig. 7,—Nematocyst lying under the skin. The wall of the vacuole has not yet been passed. Transverse section of Microstoma.

Fig. 8.—Nematocyst lying in the testis of Microstoma lineare. *Sperm.* Spermatocyte. *Te.* Testis.

Fig. 9.—Exploded nematocyst lying in the vacuole under the skin. Transverse section of Microstoma.

Fig. 10.—Outline of Microstoma lineare, showing the fully expanded pharynx when collecting Hydra. *Ph.* Pharynx.

Fig. 11.—Exploded Cordylophora nematocyst from the skin of Microstoma lineare. Only part of the thread is drawn.

Fig. 12.—Exploded Cordylophora nematocyst lying in a vacuole under the skin. From a transverse section of Microstoma lineare.

Fig. 13.—Longitudinal section through the proboscis of Polycystis nægelii. 4 mm. + 4 comp. oc.

circ.musc. Circular muscle. *Prob.* Proboscis. *ret.musc.* Retractor muscles. *Sph.* Sphincter muscles.

Fig. 14.—Part of epidermis of the proboscis of Polycystis nægelii from a transverse section. 2 mm. + 6 comp. oc.

a. Rhabdites in epidermis of proboscis.

b. Rhabdites in epidermis over the body.

Fig. 15.—Part of a crushed Stenostoma sieboldii, showing Tubularia nematocyst in vacuole.

Ne. Nematocyst. *Rh.* Rhabdite.