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The Nervous System in Some Cœlenterate Types

I. *Cœloplana*

By

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With 3 Text-figures

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Introduction

In this series of papers, I propose to describe the results of my studies on the nervous system found in some cœlenterate types. These studies have been made during my repeated visits to our Seto Marine Biological Laboratory, as well as to the Misaki Marine Biological Station of the Tokyo Imperial University. The method which was employed for the studies was the vital staining with rongalit white according to UNNA. The stain was prepared after the scheme which BOZLER (1927), HEIDER (1927) and MCCONNELL (1932) approve for their researches on the nervous system of *Rhizostoma, Beroë* and *Hydra* respectively: that is, to 20 c.c. of 0.5% methylene blue (EHRLICH) in distilled water plus 1 drop 25% HCl, was added 4 c.c. 15% rongalit (GRÜBLER) in distilled water; the mixture was warmed, filtered, and then allowed to stand about 1 day before being used. The efficacy of this mixture as a nerve stain is best during the first three days, after which it declines gradually. So that, in order to secure good results, the mixture should be renewed at least after a week. When the above mixture is added to sea water about 30 times its volume, the water turns a deep blue color. The material is put into the colored water, or placed on a slide with a small quantity of the water. In 15 to 30 minutes the nerve cells and fibers begin to stain. The suitable quantity of the stain in water varies somewhat with the material, and this will be stated in each case.

The Nervous System of Cœloplana

Historical

The first statement made on the nervous system of this aberrant ctenophore is that of ABBOTT (1907). It runs as follows: "Just outside the otolith capsule in the angles formed by the intersecting tentacular and sagittal planes are four large nerve ganglia (cf. KOROTNEFF) that send off fibers to form a sort of diffuse peripheral system, and on the other hand supply fibers that surround the lower part of the capsule as an enveloping sheath. Each ganglion is directly opposite the point of insertion of the supporting cilia on the otolith. The cells of the nerve tracts and ganglia are large, with large nuclei, and stain intensively in methyl blue" (p. 61). Further, he gives figures (Figs. A, B) in which the alleged ganglia are presented very definitely.

Next, in my paper on *Cœloplana* and *Gastrodes* (1922), I have presented my finding on the nervous system of *Cœloplana* by means of the ordinary methylene-blue vital staining method, with an illustration (Text-fig. 1). "When the staining was satisfactory, there came out an element stained deep blue which appeared like the figure. It occurs directly beneath the ventral epidermis in the regions close to the external margin of the body. It consists of cells with extremely fine but very long fibrous processes. The cell-body may be spheroidal, spindle-shaped, etc., and of somewhat variable sizes, though always much smaller than the gland cells in the epidermis, which stain somewhat with the same dye. It stains uniformly and very deeply, rendering the examination of the nucleus almost impossible. The processes given out from the cell are from two to four. They are extremely fine throughout their length; but since they take the stain as strongly as the cell-body, they are not very difficult to make out. They run largely parallel with the margin of the body, often taking a more or less undulating course. Branching and varicose appearance are not uncommon. The fibres are readily distinguished from the muscle-fibres prevailing in the same regions by being extremely fine." (pp. 44–45).

As to the presence of the "ganglia" advocated by ABBOTT, I have stated my suspicion that they are no more than the group of muscle-fibers which often produce, in sections of a contracted animal, a figure something like ganglia.

More recently, MOORE (1933) has reported that *Cœloplana*

presents reactions to certain narcotics more like those of echinoderms and worms than those of cœlenterates. Thus *Cœloplana* shows primitive but unmistakable spasms reacting to strychnine at a dilution in sea-water of 1 : 5,000. Similar effects may be obtained with atropine sulphate at 1 : 10,000, with nicotine at 1 : 10,000, and with phenol at 1 : 10,000, a series very similar to that for echinoderms and worms. In contrast to this, the sea-anemone *Anthopleura*, for instance, shows no effect of strychnine, even when the crystals are put on the oral disk; and gives only sluggish responses under atropine 1 : 2,000, and nicotine 1 : 2,000. He concludes that: "An interesting if somewhat puzzling corollary to these facts regarding *Cœloplana* is that morphological complexity does not go hand in hand with chemical differentiation" (pp. 203–204).

Thus the nervous system of *Cœloplana* presents us with a very interesting problem, more than any other part of the tissue of this curious creature. This fact was told me by Dr. A. R. MOORE, when I met him a few years ago. It gave a new impetus to my desire to elucidate the precise state of the nervous system of this form, and I carried out my renewed study with the improved technique.

Material and Methods

The observations were made during my stay in May, 1935, in the Misaki Marine Biological Station. For the material, *Cœloplana bocki* KOMAI, the commonest species, was exclusively used. The animals are removed from the alcyonacean host to which they adhere, by the spouts of water from a pipette, and placed on a slide dipped in water. After they have sufficiently spread out on the slide, the latter is transferred to the colored water which has been prepared by the method stated above. In some half to one hour the nervous elements are stained. The thin and almost transparent body is well fitted for observation under the microscope. In order to observe the nervous elements on the ventral side, the individuals which have been spread under the surface film of water are the most suitable. When several individuals of the animal, newly detached from the alcyonacean, are taken into sea water in a Petri dish, a few usually spread under the surface film. Then the proper quantity of stain is added to the water which soon becomes colored in deep blue. The individuals generally shrink to some extent; but this does not hinder observation. In due time the animal is scooped up carefully with a slide and examined.

Observations

Ventral Side

As is pointed out in my paper cited above, as well as in works by subsequent authors, the ventral side of *Cœloplana* corresponds morphologically with the surface of the outer half of the pharynx in ordinary ctenophores. The nervous elements detected on this side are as follows.

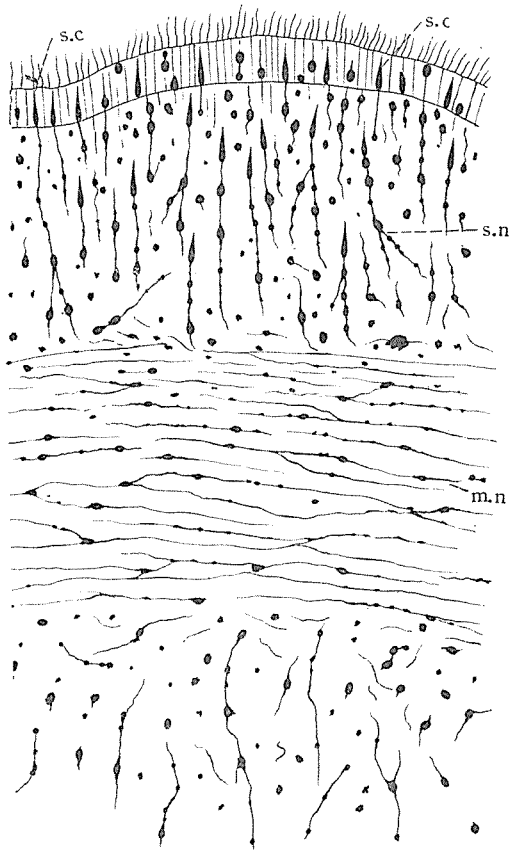

Fig. 1. Peripheral parts on the ventral side, with sensory nerves (s. n) ending in sensory cells(s. c), and motor nerves (m. n) forming a loose network. ×300

First, conspicuous elements are found in the marginal zone. (Fig. 1, s. n). These consist of bead-like bodies (cells) connected by delicate fibers which run mostly in the direction vertical to the margin. The cells are elliptical or spindle-shaped. Usually two or three of them are united together by a fiber which shows varicosity here and there. The distal ends of many of such groups are connected each to a lance-shaped body found at the very extremity of the margin (s. c). This body is a sensory cell without doubt, and the fiber is the sensory nerve. The fiber may show a few branchings, but these do not seem to form any network.

Directly internal to the above zone is found the zone containing nerve fibers which run mostly parallel to the margin (m. n). These nerves are what I was able to make out more than fifteen years ago and illustrated in the figure referred to above. The cells found here may be bipolar, tripolar, or tetrapolar; and the fibers

are often furcated or fused together, and produce a structure resembling a network. The fibers are extremely fine, but can be traced to a fairly considerable distance; varicosity also occurs very commonly. In this zone muscle fibers, both radial and circular, are found in abundance, so that it is very likely that most of the nerves occurring here are motor nerves.

The zone still more internal likewise shows bodies which are evidently nervous in nature. Cells, rather irregular in shape and taking the dye intensively, are scattered in this region. Some of the cells are isolated; but others are connected by delicate fibers, much as in the nerve cells found in the more external zones. Fewer of these cells, however, are found here than in either of the external zones mentioned above.

Dorsal Side

The short stretch of the marginal area is distinguished from all the rest of the dorsal side by the absence of gland cells (Fig. 2). This part is further characterized by the presence of nervous elements. These are much like those occurring in the corresponding zone on the ventral side. The fibers take mostly the direction vertical to the margin, and show few branchings. The lancet-like end-cells seem more scarce than on the ventral side. Still, it is more than probable that they are sensory nerves for the most part. No other region on the dorsal side seems to contain nervous elements except a part forming the aboral sense-organ to be dealt with next.

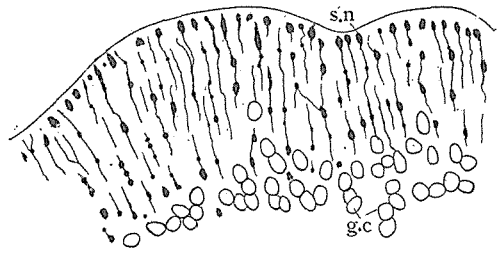

Fig. 2. Marginal Zone on the dorsal side, with sensory nerves (s. n) and gland cells (g. c). ×300

Sense-organ

As is described in my former paper (1922), *Cœloplana* is provided with an aboral sense-organ which has the essential structure of that occurring in ordinary ctenophores. The polar plate of *C. bocki* is, however, distinguished from that of these ctenophores by the fact that it is provided with three to five lobe-like processes on the margin (Fig. 3, p.). Histologically the plate is divided very sharply into two parts, namely, the marginal and central areas.

The former is made up of tall columnar cells, while the latter is lined by a more flattened epithelium.

The cells of the polar plate, especially the columnar cells on the margin, stain in methylene-blue more deeply than those in any other part of the body. This fact shows that these cells are somewhat different in nature from those of other parts. In the more peripheral region of the central area, close to the boundary between the central and marginal areas, there are found spheroidal bodies deeply stained in methylene-blue. (n. c). On account of their small size, it is hard to make out the relation of these bodies with one another or with other tissues, except that a few of them are united together by a fiber. However, their appearance, as well as their occurrence in that part, make it probable that these bodies are nerve cells. Nothing else was found in the parts forming the statocyst, nor in the regions surrounding it, which would appear as a nervous element.

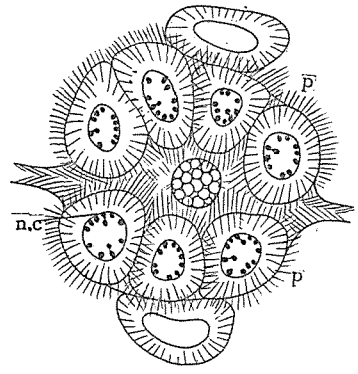

Fig. 3. Polar plates with nerve cells (?) (n. c). ×150

Remarks

The observations stated above show clearly that *Cœloplana* has a nervous system of the cœlenterate type. The nerve cells are bipolar or multipolar and form a sort of network in certain regions; but there is no centralization of the nervous elements. As compared with the nervous system of the ordinary ctenophore, the following two features seem salient: first, the high development of nerves in the marginal region of the ventral, as well as of the dorsal, side; and second, the absence of nerves on the dorsal side except in the marginal region. The highly thigmotropic habit of the animal, and also the spasmodic reactions to narcotics, discovered by MOORE, are probably due to the characteristic stated first. The second characteristic has undoubtedly resulted from the differentiation of the dorsi-ventrality of this animal. There is no possibility of the presence of ganglia in any part of the body. The "ganglia" in ABBOTT's paper is probably nothing but the sphincter muscles of the statocyst, as mentioned in my former paper.

Summary

1. The nervous system of *Cœloplana bocki* KOMAI has been studied by the aid of vital staining method with rongalit white.

2. The dorsal side contains no nerves except in the marginal zone where nerve cells, probably sensory, are found in abundance.

3. The ventral side shows nervous elements all over. But the marginal region is especially rich in these elements. Of this region the outermost zone contains nerves which are probably sensory, while the next zone has nerves probably motor in nature.

4. In polar plates nerve-cell-like bodies occur in the region between the central and marginal areas. Otherwise there is no element resembling nerves in the sense-organ nor in the parts surrounding it.

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