SYMPATHETIC AND PARASYMPATHETIC NERVES IN THE ORBIT OF THE CAT

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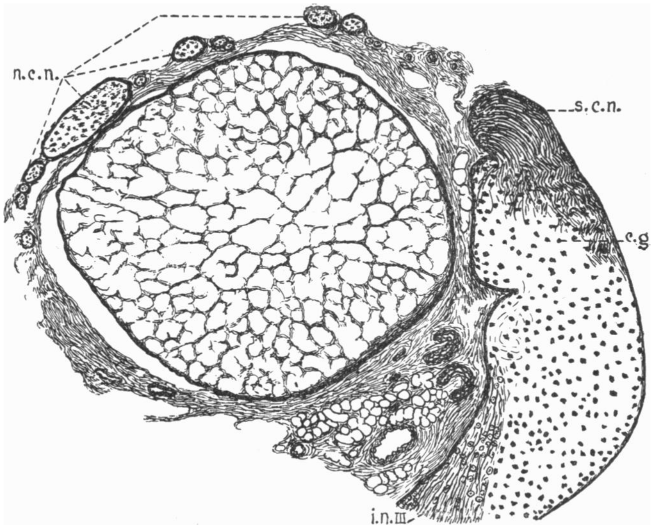
INTRODUCTION

Cranial autonomic ganglia in mammalian species commonly are described as having three roots, viz. a motor, a sensory and a sympathetic root. The motor root carries pre-ganglionic fibres which arise in the brain stem and terminate in the ganglion in synaptic relationship with ganglion cells. The sympathetic root consists of the post-ganglionic sympathetic fibres which arise in the superior cervical ganglion and extend cephalad *via* the internal carotid plexus. The sensory root consists of afferent cranial nerve components. Both the sympathetic and the sensory fibres pass through the ganglion without interruption and become incorporated in the nerves which arise from it. The motor and sympathetic roots of the spheno-palatine ganglion, for example, are derived from the nerve of the pterygoid canal. This nerve is formed by the union of the great superficial petrosal nerve, which conveys pre-ganglionic fibres, and the deep petrosal nerve, which conveys sympathetic fibres. The sensory root is composed of the spheno-palatine nerves, which convey most of the sensory fibres which pass through the spheno-palatine ganglion. In view of these anatomical relationships, it would be impossible, by surgical intervention, to eliminate the parasympathetic fibres to the organs innervated by the nerves from the spheno-palatine ganglion and still retain the sympathetic supply to these organs, because removal of the spheno-palatine ganglion or section of the nerves arising from it would interrupt not only the parasympathetic fibres which arise in the ganglion but also sympathetic fibres which pass through it.

The anatomical relationships of the ciliary ganglion, according to most accounts, are comparable to those of the spheno-palatine. The inferior ramus of the oculomotor nerve is designated as the short or motor root; fibres derived from the cavernous plexus compose the sympathetic root; and fibres derived from the nasociliary nerve constitute the long or sensory root. The sympathetic root usually fuses with the sensory root before entering the ganglion; consequently, branches of the nasociliary nerve contain both sensory and sympathetic fibres. Removal of the ciliary ganglion in such cases results in degeneration not only of the sympathetic fibres but also of all sympathetic fibres passing through the ganglion. It is obvious that whenever most of the sympathetic fibres reach the eye by way of the ciliary ganglion,[1] the parasympathetic fibres cannot be destroyed without complete destruction of the sympathetic fibres associated with them. In certain species the relationships of the nerves to the ciliary ganglion undoubtedly are as summarised above. A study of the ciliary ganglion in the cat, however, shows that in this species the relationships indicated above do not obtain except with respect to the motor root. In this species sympathetic fibres usually do not traverse the ciliary ganglion. Jegerow (1887) failed to detect a root to the ciliary ganglion in cats. Anderson (1905) also failed to find one. Dupas (1924) states that the



Text-figs. 1–3. A series of sketches of sections of orbital nerves, made by bleaching retouched photomicrographs. These sections were selected from the serial sections of one orbit.

Text-fig. 1. The ciliary ganglion is shown with fibres of the third nerve entering and the fibres of the short ciliary nerves leaving the ganglion. Branches of the nasociliary nerve are found above and to one side of the optic nerve.

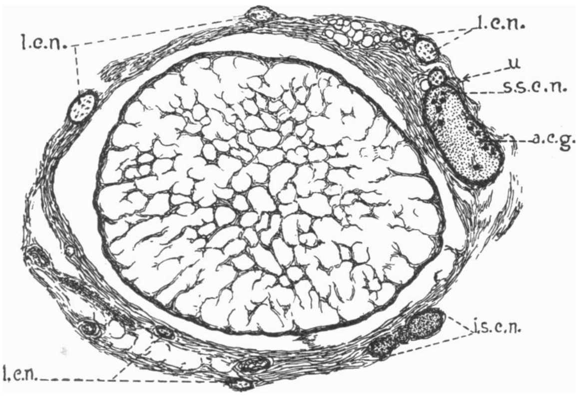
ciliary ganglion receives directly only a single root which is the motor one. He found macroscopically no sympathetic root, although he thought that sympathetic fibres might reach the ganglion through the motor root.

OBSERVATIONS

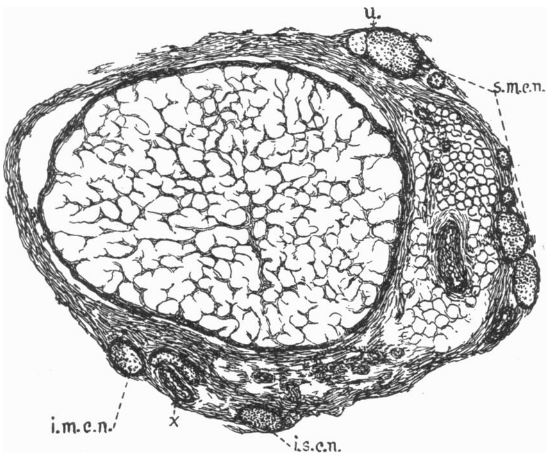
Sections of the ciliary ganglion. Serial sections of the ciliary ganglion of the cat prepared by the pyridine silver method reveal no bundles of sympathetic or sensory nerve fibres passing through the ganglion. Since the neurons are widely separated from one another in the ciliary ganglion (Plate I, fig. 1), the types of fibres and their distribution within the ganglion can be readily studied. No fibres of very large or very small diameter are present and except

[1] In serial sections of the one orbit of a monkey practically all of the sympathetic fibres to the eye did join the ciliary ganglion.

for terminal pericellular networks about the neurones, within the ganglion, all fibres appear to be myelinated. In none of the ganglia of the cat studied could bundles of small, unmyelinated fibres be found within the ganglion and no nerves with unmyelinated fibres joined any part of the ciliary ganglia studied in serial sections. In a series of sections of the ciliary ganglion of the monkey (Plate I, fig. 2), by contrast, one or more small nerves each containing



Text-fig. 2. Long ciliary nerves joining the supero-lateral short ciliary nerve and its rami.



Text-fig. 3. Long ciliary nerves joining the inferior short ciliary nerve and its rami.

unmyelinated fibres, could be traced to the ganglion. As these bundles are traced through the ganglion, they remain intact until they enter the short ciliary nerves.

Sections of the oculomotor and ciliary nerves. A study of serial sections of the nerves connected with the ciliary ganglion of the cat likewise shows a dissociation of parasympathetic nerve fibres from the sympathetic and sensory nerve fibres; at least close to the ganglion.

The ramus of the oculomotor nerve (Plate II, fig. 4) which carries the pre-ganglionic fibres to the ciliary ganglion consists chiefly of large and small myelinated fibres. Pyridine silver preparations of this ramus (Plate II, fig. 3) reveal few unmyelinated fibres or none at all. The smaller myelinated fibres, which become aggregated at one side of the nerve, are those which enter the ganglion as pre-ganglionic fibres from the oculomotor nerve.

The sections of the short ciliary nerves taken near the ganglion are composed entirely of small myelinated fibres of nearly uniform diameter. This observation has been confirmed in both osmic acid (Plate II, fig. 6) and silver preparations (Plate II, fig. 5). Myelination of post-ganglionic fibres is uncommon except in the short ciliary nerves. The histological appearance of the short ciliary nerve, therefore, is particularly favourable for detecting sympathetic fibres wherever any are present, since the latter are mainly unmyelinated.

Sections of the short ciliary nerves taken farther distally, however (text-figs. 2 and 3), in almost all cats, show that branches of long ciliary nerves unite with them before they reach the eyeball.

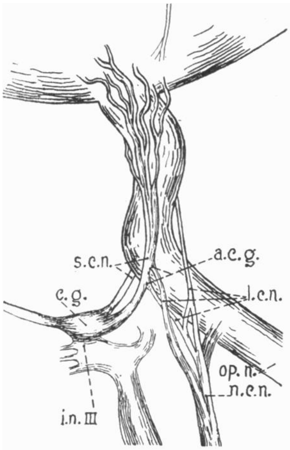
The long ciliary nerves are composed of large myelinated, small myelinated (Plate II, fig. 8) and unmyelinated fibres (Plate II, fig. 7). The unmyelinated fibres probably are in part sympathetic, and the larger myelinated ones sensory.

Whenever a union of long and short ciliary nerves occurs, the large myelinated fibres (text-fig. 1) and the unmyelinated fibres from the nasociliary nerves can always be detected in the resulting mixed nerve, since they appear in sharp contrast to the smaller, myelinated parasympathetic fibres of the short ciliary nerves. At the places where the first long ciliary nerves superiorly join the short ciliary nerves, it is not uncommon to find scattered ganglion cells in the short ciliary nerves (text-fig. 2). These are designated as accessory ciliary ganglia. The functional connections of these cells undoubtedly are affected through pre-ganglionic fibres from the third nerve which traverse the ciliary ganglion and the short ciliary nerves until the cells are reached.

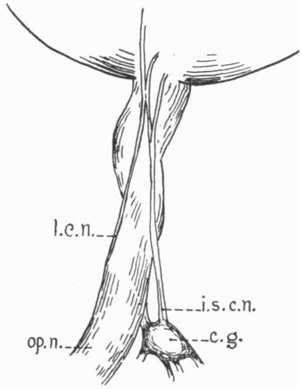
The ciliary ganglion and the ciliary nerves—gross dissection

The microscopic findings as described above were confirmed in a series of dissections made with the aid of a dissecting microscope (text-figs. 4–7).

The demonstration of the ciliary nerves is facilitated by treating the orbital contents, fixed in a solution of 10 per cent. formalin, washed in water, and then partially dissected with a 0·5 per cent. solution of silver nitrate for about 12 hours. In such material the nerves appear dark brown while other tissues have a very light brownish colour. The darkness of the other tissues is greater when stronger silver solutions are used; when the treatment with the silver nitrate is prolonged; or when the silvered material has been exposed to the light for long periods of time. If dissections are made under water with the use of a dissecting microscope and a projection lamp the differentiation, however, remains good for a long time providing the material, when not in use, is kept in distilled water in a dark place. The ganglia in the preparations after being in the silver nitrate are usually much lighter than the nerves; consequently with the use of the microscope even the position of accessory ciliary ganglia of any size can be readily determined.



Text-fig. 4.



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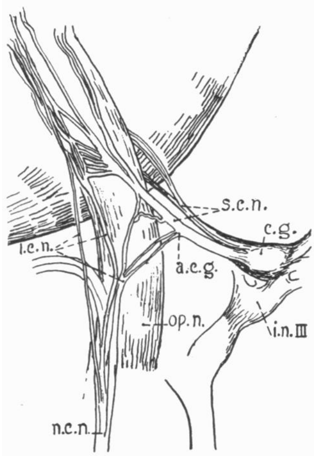

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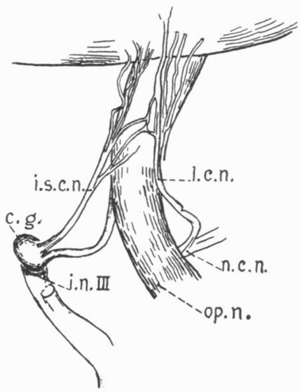

Text-fig. 7.

Text-figs. 4–7. A series of sketches of dissections of orbital nerves made from photographs. The relations of ciliary ganglion, short ciliary nerves, and long ciliary nerves are shown.

The main ciliary ganglion is a small, flattened, ovoid or triangular body located in the deep part of the orbit, lateral to the optic nerve and superior to the inferior ramus of the oculomotor nerve. From the inferior ramus of the oculomotor nerve, pre-ganglionic fibres enter the ganglion where they form synapses with ganglion cells. Besides the inferior ramus, no other nerves joining the ganglion have been found. The nerves which arise from the ganglion usually consist of two short ciliary nerves which extend forwards from the anterior border of the ganglion. The superior one, which is the larger, lies on the lateral surface of the optic nerve in the first part of its course and then on the lateral and supero-lateral surface, where it divides into numerous small branches. The inferior and smaller one usually bifurcates as it leaves the ciliary ganglion. The two branches then pass lateral to the optic nerve and beneath it where they also divide into a number of small nerves. These, however, are never quite as numerous as those of the superior group.

The ciliary nerves and their branches course along the optic nerve to the eyeball together with the long ciliary nerves. Although in the cat no long ciliary nerves have been found to join the ganglion, it is not uncommon to find both short ciliary nerves or their branches joined by long ciliary nerves between the ganglion and the eyeball. The number of long ciliary nerves is variable. Two branches or a bifurcated branch or a single nerve may join the proximal third of the superior short ciliary nerve, and it is at these points of union that accessory ciliary ganglia usually occur. Beyond this region superiorly a variety of conditions may appear from a complete absence of further union between long and short ciliary nerve branches to a union of all remaining long ciliary branches with short ciliary branches. The latter usually takes place close to the eyeball. In the case of the ciliary nerve branches beneath the optic nerve where they are not so numerous, only single or double long ciliary nerves appear, and they may not join the short ciliary nerve branches until close to the eyeball or they may form with the short ciliary nerve branches a simple network of fibres along the distal two-thirds of their length.

Whenever union of long ciliary branches with short ciliary branches occurs, mixed nerves result which contain sympathetic and sensory fibres from the former and parasympathetic fibres from the latter (a section is shown in Plate II, fig. 9).

In the preceding description a summary of the general details only has been attempted. Specific individual details have not been included. It is to be pointed out, however, that variations in the relationships between long and short ciliary nerves differ from individual to individual, and also between the nerves of the orbit of the one side and the nerves of the orbit of the opposite side of the same individual.

SUMMARY

The results of the anatomical study may be summarised as follows:

1. The so-called sympathetic and the sensory roots of the ciliary ganglion are not found in the cat.

2. The short ciliary nerves when they first arise from the ciliary ganglion contain only post-ganglionic parasympathetic fibres.

3. Sympathetic fibres become incorporated in the short ciliary nerves only after those nerves have been joined by long ciliary nerves somewhere between the ganglion and the eyeball.

4. In the orbit of the cat there is at least a partial separation of post-ganglionic sympathetic and parasympathetic fibres which innervate the eye:

(*a*) since the ciliary ganglion has no sympathetic fibres passing through it; (*b*) since short ciliary nerves are separate for some distance.

It follows from these conclusions that, by careful operative procedure, the eye can be deprived of its post-ganglionic parasympathetic supply by removal of the ciliary ganglion without great disturbance to its sympathetic supply.

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EXPLANATION OF PLATES

PLATE I

Fig. 1. Photomicrograph of a typical section through the ciliary ganglion of a cat.

Fig. 2. Photomicrograph of a section through the ciliary ganglion of a monkey which shows a long ciliary nerve in section that passes through the ganglion.

PLATE II

Fig. 3. Photomicrograph of a section of the inferior ramus of the oculomotor nerve. Pyridine silver method.

Fig. 4. Photomicrograph of a section of the inferior ramus of the oculomotor nerve. Osmic acid method.

Fig. 5. Photomicrograph of a section of one of the short ciliary nerves, taken near the ciliary ganglion. This nerve was photographed at a magnification higher than that used for other nerves on this plate. Pyridine silver method.

Fig. 6. Photomicrograph of a section of one of the short ciliary nerves taken near the ganglion. Osmic acid method.

Fig. 7. Photomicrograph of a section of a long ciliary nerve. Pyridine silver method.

Fig. 8. Photomicrograph of a section of a long ciliary nerve. Osmic acid method.

Fig. 9. Photomicrograph of a section of a mixed ciliary nerve. A short ciliary nerve has been joined by long ciliary nerves, whose large myelinated sheaths show clearly.

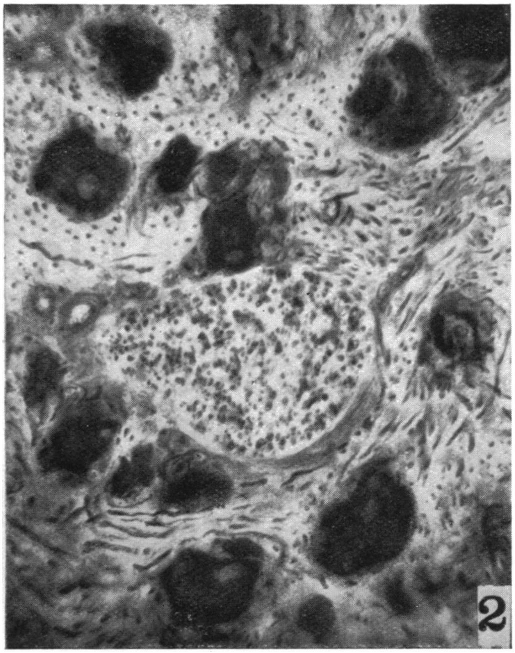
ABBREVIATIONS

Text-figs. 1–3

a.c.g.	Accessory ciliary ganglion.
c.g.	Ciliary ganglion.
i.m.c.n.	Inferior mixed ciliary nerves.
i.n.III.	Fibres of inferior ramus, oculomotor nerve entering the ciliary ganglion.
i.s.c.n.	Inferior short ciliary nerves.
l.c.n.	Long ciliary nerves.
n.c.n.	Branches of nasociliary nerve.
s.c.n.	Fibres of short ciliary nerves leaving the ciliary ganglion.
s.m.c.n.	Supero-lateral mixed ciliary nerves.
s.s.c.n.	Supero-lateral short ciliary nerves.
u.	Points of union between supero-lateral short ciliary nerves and long ciliary nerves.
x.	Points of union between inferior short ciliary nerves and long ciliary nerves.

Text-figs. 4–7

a.c.g.	Accessory ciliary ganglion.
c.g.	Ciliary ganglion.
i.n.III.	Inferior ramus, oculomotor nerve to ciliary ganglion.
i.s.c.n.	Inferior short ciliary nerves.
l.c.n.	Long ciliary nerves.
n.c.n.	Nasociliary nerves.
op.n.	Optic nerve.
s.c.n.	Short ciliary nerves.



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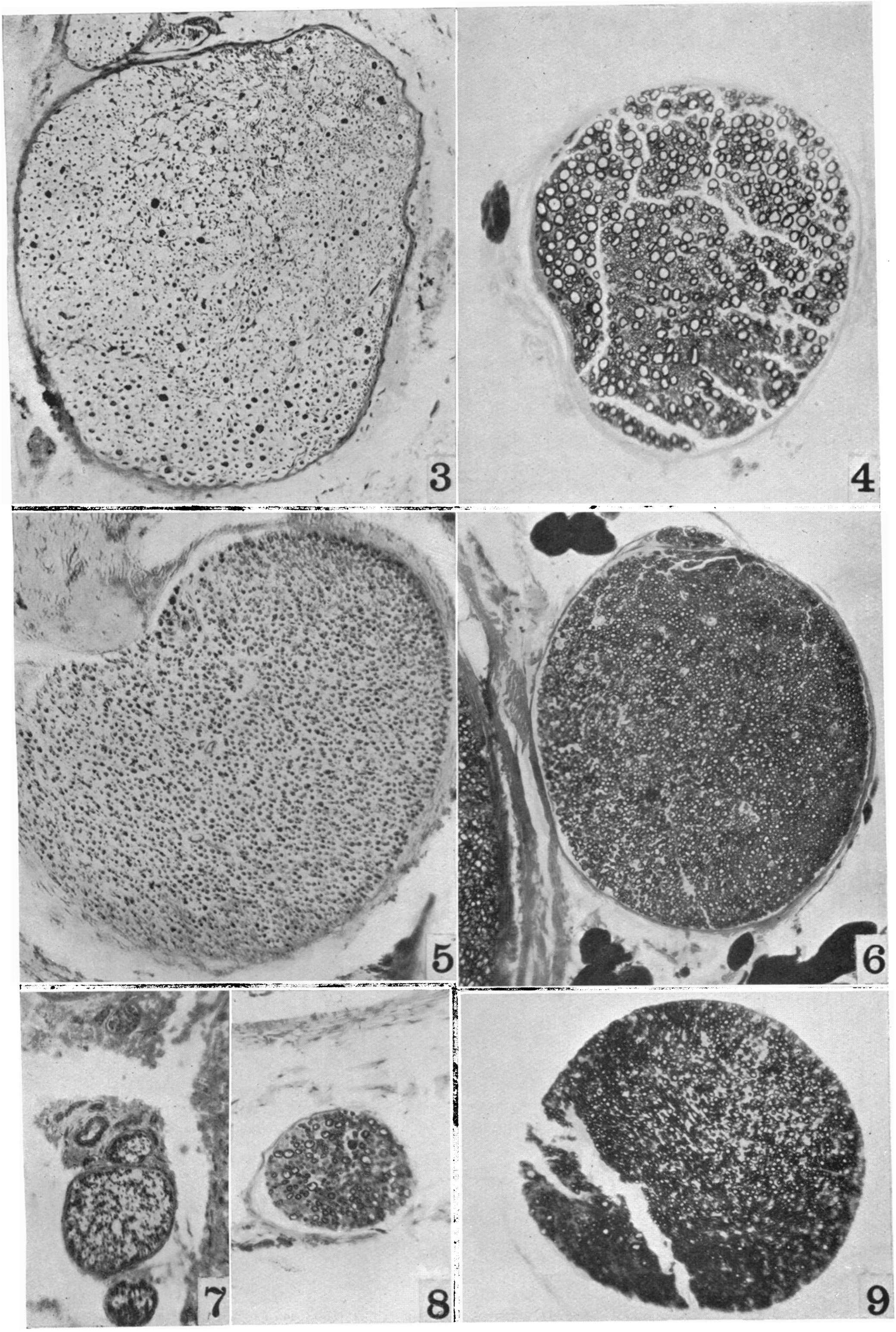

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