

THE PELVIC SPLANCHNIC NERVES: AN EXAMINATION  
INTO THEIR RANGE AND CHARACTER. By N. BISHOP  
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THE name 'pelvic splanchnic nerve' has here been applied to those parts of the sacral plexus distributed to the pelvic viscera, as suggested by Gaskell, for it appears to supply an appellation more convenient than the more commonly used 'nervus erigens,' in that it indicates a nerve located in a certain position, and having a certain general distribution, without committing one to any definition as to the functions of the nerve. Such a definitive, yet non-committing, name would seem to well fit it with an ideal nomenclature such as Huxley craved.<sup>1</sup>

*The Nerve in Man.*

The early descriptions of the nerve are mostly found in connection with work on the uterine nerves, in dissections of adult and foetal subjects, but the references to the particular origin of the pelvic splanchnics are not very full. Willis, Eustachius, and Haller were among the early workers on these parts. The work of Jo. Gottl. Walter (1) is of a specially noteworthy character. The illustrated descriptions by Tiedemann (2) of the uterine and sacral nerves are well known, and his figures appear to have formed the basis of many text-book diagrams.

Two English workers follow—Robert Lee (3) and Thomas Snow Beck (4)—both of whom refer to the connection of the sacral nerves with the pelvic viscera. The latter is very explicit in his description, and draws an analogy between the arrangements of the abdominal splanchnics and these visceral sacral branches.

The work of Hirschfeld and Leveillé (5) is well known, their figures appearing in the text-books of to-day. In the mono-

<sup>1</sup> On the crayfish.

graph of Frankenhaeuser (6) on the uterine nerves, their sacral connections are carefully noted and shown in the admirable illustrations.

The results of the more recent of these dissections give the origin of the pelvic splanchnics as being mainly from the third sacral nerve, whilst smaller portions arise from the second or fourth nerves, rarely from both.

#### *The Nerve in Lower Animals.*

With the growth of experimental examination of nerves, subsequent to the work of Bell, we find numerous investigations into these nerves. Of these, the following may be mentioned here:—

Budge (7) may be credited with the earliest efforts. He showed from experiments on dogs that the bladder was innervated by two sets of nerves,—one from the hypogastric plexus, the other from the anterior roots of spinal nerves, including the first, second, and third sacral.

Gaskell (8) also showed on the dog “an outflow of nerve fibres of the smallest calibre from the second and third sacral nerves (30th and 31st spinal); these constitute the main portion of the *nervi erigentes* . . . they send branches in two directions, upwards to the inferior mesenteric ganglion, and downwards to the bladder, rectum, and generative organs.”

Langley (9) found in the rabbit that a set of motor fibres reached the pelvic viscera from the second, third, and fourth sacral nerves, perhaps also from the first. The majority issued from the third and fourth.

Sherrington (10) gives the results of his experiments and dissections on two animals, the cat and a monkey (*Macacus rhesus*).

Cat.—In post-fixed plexus, origin from sub-thoracic nerves VIII, IX, and X. In pre-fixed plexus, arising from sub-thoracic nerves VII, VIII, IX, and X. Here the VIII sub-thoracic equals the I sacral.

Monkey.—Post-fixed—sub-thoracic nerves VIII, IX, and X. Pre-fixed—sub-thoracic nerves VII, VIII, IX, and X. Here the VII sub-thoracic equals the I sacral.

Langley (11) gives their origin in the cat from the II sacral in the main, with a variable number of fibres from the I and III sacral. These nerves he believes to be comparable to the II, III, and IV sacral in man.

Griffiths (12) describes the nerves in the dog as arising usually by two roots, one large and one small, the larger arising from the II sacral, the smaller usually from the first, but sometimes from the third, or there may be two small roots from both first and third. These nerves he describes as being almost entirely composed of small medullated fibres, measuring from 2 to 3  $\mu$  in diameter.

Langley and Anderson (13), in a detailed examination into the constitution of the nerves in the cat, find that a complete nerve contains normally about 3500 medullated fibres; of these, one to two dozen are from 7 to 12  $\mu$  in diameter, several hundreds are 4 to 5  $\mu$ , and nearly all the rest are quite small.

*Present Examination—Methods and Scope.*

In this examination into the nerve in the human subject, I have endeavoured to obtain results similar to those obtained in my earlier examination of the lumbar rami (14), and to those obtained by Langley and Anderson for the cat.

The complex arrangements of the pelvic nerves have necessitated more elaborate methods than those adopted for the lumbar nerves. Foetuses ranging from the seventh month (39 cm.) to full time (55 cm.) were used. The subjects were dissected immediately on receipt in the fresh state; the sacral nerves having been severed high up in the spinal canal, the whole plexus and its connections were removed and placed in osmic acid (1 per cent. solution) for twenty-four hours, then in weak alcohol for a short time.

The plexus was now arranged in a dissecting-trough according to the beads affixed to the various nerves, and the sketch previously made for recognition purposes. Lengths of the II, III, and IV sacral nerves were then removed for embedding.

The grosser connective tissue being removed, the nerves were exposed to the action of a 10 per cent. solution of nitric acid for the purpose of softening the remaining connective tissue.

This softening is, in most cases, necessary, for otherwise it is rarely possible to retain the plexus in anything approaching the natural position during dissection. It has, however, the disadvantages of removing some of the osmic stain, and of softening the nerves. To avoid damage to the nerves, it seems better to examine their condition whilst exposed to the acid, rather than to work by a time limit. (See Note, p. 393.)

The nerve strands forming the pelvic splanchnics were then cleaned, their proximal ends freed from neighbouring strands, and their ultimate source noted. Parts of these strands were excised, teased out, and the characters and number of the nerve fibres therein ascertained. It was found to be impracticable to make anything like a reasonably accurate individual count of such a mass of small fibres, I therefore estimated their numbers with the aid of a micro-millimetre eyepiece; the number of fibres in one bundle of a preparation having been counted individually, the contents of the remaining bundles were estimated by comparison of size to the counted bundle.

These methods of investigation were employed in six cases in all, which, from the use of both sides, give twelve plexuses. The greater number of these are of the male sex, the difficulty in obtaining fresh material prevented a more equal selection of subjects.

Appended are the drawings of the various plexuses. Each of these is the result of the superposition of two drawings,—one that of the plexus exposed by simple dissection, the other the result of the minute dissection of the pelvic splanchnics with the aid of the simple microscope. To each of these corresponds an analytical table giving the results of the examination of the plexus and of each nerve strand, and from these analyses a general table has been prepared which states the form of plexus found, the number of fibres in connection with each spinal nerve, and the average number for each, from nerves 27 to 29 inclusive.

#### *Results.*

From the table it will be seen that the main outflow of the pelvic splanchnic nerve is from the 28th spinal, or III sacral nerve; the outflow by the 27th and 29th nerves is seen to vary

## ANALYSIS OF SPLANCHNIC NERVES.

Mark of Subject.	Sex.	Length or Age.	Side of Body.	Form of Plexus.	Nerve 27 = II. Sac.		Nerve 28 = III. Sac.		Nerve 29 = IV. Sac.	
					No. of Strands.	No. of Fibres.	Strands.	Fibres.	Strands.	Fibres.
M	♀	54 cm.	Right.	Nv. furcal. = $\frac{1}{2}$ IV. Lmb. Sup. Glut. = 5, 1, 4.	0	...	2	535	6	2405
			Left.	Nv. furcal. = $\frac{1}{2}$ IV. Lmb. Sup. Glut. = 5, 1, 4, 2.	0	...	3	1165	6	2020
G	♂	50 cm.	Right.	<i>XII Rib absent.</i> Nv. furcal. = $\frac{2}{3}$ 24th Spinal. Sup. Glut. = 4, 5, 1.	2	280	6	1710	2	50
			Left.	Do.	3	340	6	1990	0	...
H	♂	46 cm.	Right.	Nv. furcal. = $\frac{1}{2}$ IV. Lmb. Sup. Glut. = 5, 1, 2, 4.	1	20	4	1400	2	170
			Left.	Nv. furcal. = < IV. Lmb. Sup. Glut. = 5, 1, 4 (2?)	0	...	5	Staining defective.	3	Staining defective.
N	♂	53 cm.	Right.	Nv. furcal. = $\frac{1}{2}$ IV. Lmb. ex. abd. one-fourth part to Obturator nv. Sup. Glut. = 4, 5, 1. Lev. Ani. = 2, 3, 4.	2	550	6	2600	1	320
			Left.	Nv. furcal. = $\frac{1}{2}$ IV. Lmb. Sup. Glut. = 4, 5, 1. Lev. Ani. = 2, 3, 4.	3	890	5	2800	1	500
K	♀	39 cm.	Right.	<i>XII Rib absent.</i> Nv. furcal. = $\frac{2}{3}$ 24th Spinal. Sup. Glut. = 4, 5, 1.	1	150	4	510	1	50
			Left.	Do.	3	300	4	700	0	...
L	♂	55 cm.	Right.	Nv. furcal. = $\frac{2}{3}$ IV. Lmb. Sup. Glut. = 5, 4, 1.	0	...	7	2425	2	570
			Left.	Do.	2	300	8	2700	1	420
Averages:—					1.5	200	5	1620	2	590

considerably; that in connection with the 29th nerve contains most commonly a greater number of fibres than that arising from the 27th nerve. In no case could I trace any connection with the 26th spinal nerve.

The sizes of the nerve fibres are similar to those given for other animals, being in the main of the small medullated class, and measuring from one to three micro-millimetres in diameter. There is also a small and variable number of larger fibres.

In two instances (K left and L left) serial sections were taken of the splanchnic nerve and its sacral connections, from the sacral roots to the appearance of ganglia within the pelvic plexus upon the bladder-walls. The details of these two plexuses, as given in figs. 10 and 12, were added to the drawings of the simple dissections from these serial sections.

The relation of the age of the foetus, as indicated by its length, to the number of medullated fibres in the pelvic splanchnic, is noteworthy.

The general average works out at	2400
The average for subjects of above 50 cm. length	3240
The average for subjects 50 cm. length and below	1540

The variation is doubtless due to the degree of development of the medullated sheath.

#### *Sacral Branch to the Hypogastric Plexus.*

In the reference given above to Gaskell's paper (8), there will be noticed the statement that, in the dog, branches of the pelvic splanchnic pass upwards to the inferior mesenteric ganglion. Langley and Anderson (15), working by degeneration methods on the cat, find that in that animal:—(a) the sacral nerves may send to the hypogastric nerve of the same side two or three fibres which rise in the nerve for at least two-thirds of its course; (b) besides these, several fibres pass from the sacral nerves to the hypogastric nerve, and thence curl backwards and run to the bladder, etc.

Quain (16), referring to this point, says, "a few of the pelvic splanchnic fibres may turn upwards to the inferior mesenteric ganglion"; but it is not quite clear whether the reference is to a dissection in the human body, or the suggestion of a possible

likeness to that found in the dog by Gaskell. In my dissections of the human subject no such upward branches could be found. The splanchnics mingled with the hypogastrics in the pelvic plexus, and those fibres which were found to be in loose connection with the hypogastrics before the meeting in the plexus, could be traced thence into the plexus and to the bladder. No direct passage of fibres from one to the other of the supplying nerves could be found. As to the presence of fibres similar to the few ascending fibres in the cat, these were found by degeneration methods; simple dissection cannot decide their presence or absence.

*Relative Proportion of Hypogastrics and Pelvic Splanchnics.*

In comparing the plexuses of two subjects in which minute dissection had not been begun, the sizes of the pelvic splanchnics and of the hypogastrics seemed to suggest the possibility of some proportion between them, in the direction of an inverse ratio, for the hypogastrics of the one body appeared small in comparison with the splanchnics, whilst in the other body there was a reverse appearance. Subsequent dissection did not bear out this apparent proportion.

*Forms of Plexuses.*

I have used as guides for the classification of the plexuses the size of the contribution of the 24th spinal nerve to the lumbosacral cord and the ultimate origin of the superior gluteal nerve. These form a reliable and at the same time readily ascertainable indicator.

Examination of the table of results given here, and of the paper on the lumbar rami (14), will show that the forms were most commonly those of the medium and rather anterior varieties, and that when a marked diversion from the average has been found, it has been in favour of the anterior forms, as witness the three cases in which only eleven ribs were present. These cases therefore support Rosenberg's theory of the phylogenetic shortening of the vertebral column, and are against Paterson's contention on this point (17).

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- (4) THOMAS SNOW BECK, "On the Nerves of the Uterus," *Phil. Trans.*, 1845 (xvi.).
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- (10) SHERRINGTON, "The Lumbo-sacral Plexus," *Jour. of Physiol.*, vol. xiii., p. 640.
- (11) LANGLEY, *Jour. of Physiol.*, vol. xv., p. 235.
- (12) JOSEPH GRIFFITHS, "Observations on the Urinary Bladder and Urethra," *Jour. of Anat. and Physiol.*, vol. xxix., p. 62.
- (13) LANGLEY and ANDERSON, *Jour. of Physiol.*, vol. xix., p. 377.
- (14) HARMAN, *Jour. of Anat. and Physiol.*, vol. xxxii., p. 403.
- (15) LANGLEY and ANDERSON, *Jour. of Physiol.*, vol. xvii., p. 171.
- (16) *Quain's Anatomy*, vol. iii., part ii., p. 371 (10th ed.).
- (17) PATERSON, A. M., "The Origin and Distribution of the Nerves of the Lower Limb," *Jour. of Anat. and Physiol.*, vol. xxviii., p. 186. "The Position of the Mammalian Limb," *Jour. of Anat. and Physiol.*, vol. xxiii., p. 298.

## REFERENCES TO FIGURES.

*n.f.*, nervus furcalis. *q.f.*, nerve to quadratus femoris. *o.i.*, nerve to obturator internus. *g.s.*, great sciatic nerve. *g.s.per.*, do., peroneal division. *g.s.pop.*, do., int. popliteal division. *sp.gl.*, superior gluteal nerve. *p.y.*, nerve to pyriformis. *s.s.*, small sciatic nerve. *i.gl.*, inferior gluteal nerve. *pd.*, pudic nerve. *p.spl.*, pelvic splanchnic nerve. *hyp.*, hypogastric nerve. *p.pl.*, pelvic plexus on bladder. *l.a.*, levator ani nerve.

*Note.*—I have since obtained better results in loosening the connective tissue by prolonged soaking in water 98, glycerine 1, nitric acid 1; thus were treated 'M' and 'N,' which replace earlier dissections. 'L' was not treated with acid, it being a remarkably open plexus.



'M.' right. ♀. 54 cm. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	0	...	...
III. s.	1	35	
„	2	500	535
IV. s.	3	450	
„	4	500	
„	5	675	
„	6	320	
„	7	160	
„	8	300	2405

'M.' left. ♀. 54 cm. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	0	...	...
III. s.	1	255	
„	2 <sup>(3)</sup>	780	
„	3	180	1165
IV. s.	4	170	
„	5 <sup>(3)</sup>	370	
„	6 <sup>(4)</sup>	490	
„	7 <sup>(2)</sup>	320	
„	8 <sup>(2)</sup>	190	
„	9	480	2020

[The small figure bracketed after the index number of the ramus indicates the number of distinct bundles within the ramus.]

'G.' right. ♂. 50 cm. XIIth Rib absent. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	1	120	
"	2	160	280
III. s.	3	70	
"	4	350	
"	5 <sup>(2)</sup>	{ 240 } { 450 }	
"	6	400	
"	7	200	1710
IV. s.	8	20	
"	9	30	50

'G.' left. ♂. 50 cm. XIIth Rib absent. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	1	160	
"	2	280	340
III. s.	3 <sup>(2)</sup>	{ 200 } { 300 }	
"	4	240	
"	5	300	
"	6	450	
"	7	350	
"	8	150	1990
IV. s.	Nil.	Nil.	Nil.

'H.' right. ♂. 46 cm. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	1	20	20
III. s.	2 <sup>(2)</sup>	350	
”	3 <sup>(2)</sup>	450	
”	4	200	
”	5	400	1400
IV. s.	6	70	
”	7	100	170

'H.' left.' ♂. 46 cm. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	Nil.	Nil.	Nil.
III. s.	1-5	Staining defective.	
IV. s.	6-7	”	

'N.' right. ♂. 53 cm. *Analysis*:—

Nerve.	Ramus.	Fibres.	Total.
II. s.	1 <sup>(2)</sup>	300	
"	2 <sup>(2)</sup>	250	550
III. s.	3	220	
"	4	500	
"	5 <sup>(2)</sup>	480	
"	6	600	
"	7	300	
"	8	400	2600
IV. s.	9	320	320

'N.' left. ♂. 53 cm. *Analysis*:—

Nerve.	Ramus.	Fibres.	Total.
II. s.	1 <sup>(2)</sup>	300	
"	2	210	
"	3	380	890
III. s.	4	110	
"	5 <sup>(2)</sup>	700	
"	6	350	
"	7	400	
"	8 <sup>(4)</sup>	470	2030
IV. s.	9	500	500

'K.' right. ♀. 39 cm. XIIth Rib absent. *Analysis* :—

*Medullation incomplete.*

Nerve.	Ramus.	Fibres.	Total.
II. s.	1	150	150
III. s.	2	70	
„	3	90	
„	4	150	
„	5	200	510
IV. s.	6	50	50

'K.' left. ♀. 39 cm. *Analysis* :—

Details of this Plexus from serial sections.

Nerve.	Ramus.	Fibres.	Total.
II. s.	1 <sup>(3)</sup>	300	300
III. s.	2	100	
„	3	250	
„	4	150	
„	5	200	700
IV. s.	...	Nil.	Nil.

'L.' right. ♂. 55 cm. *Analysis* :—

Nerve.	Ramus.	Fibres.	Total.
II. s.	Nil.	Nil.	Nil.
III.	1	470	
"	2	220	
"	3	520	
"	4 <sup>(2)</sup>	575	
"	5 <sup>(2)</sup>	210	
"	6	150	
"	7	280	2425
IV. s.	8	320	
"	9 <sup>(2)</sup>	250	570

'L.' left. ♂. 55 cm. *Analysis* :—

Details of this Plexus from serial sections.

Nerve.	Ramus.	Fibres.	Total.
II. s.	1	130	
"	2	270	300
III. s.	3 <sup>(8)</sup>	700	
"	4	450	
"	5	160	
"	6 <sup>(27)</sup>	820	
"	7	570	2700
IV. s.	8	120	
"	9	300	420

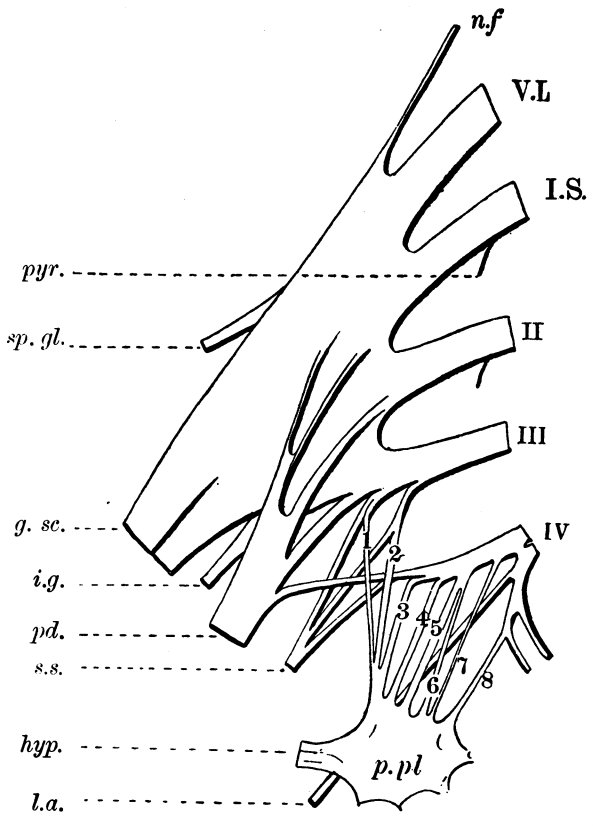


FIG. 1.—Subject, 'M,' right side. (♀ 54 c.m.)

11748  
50

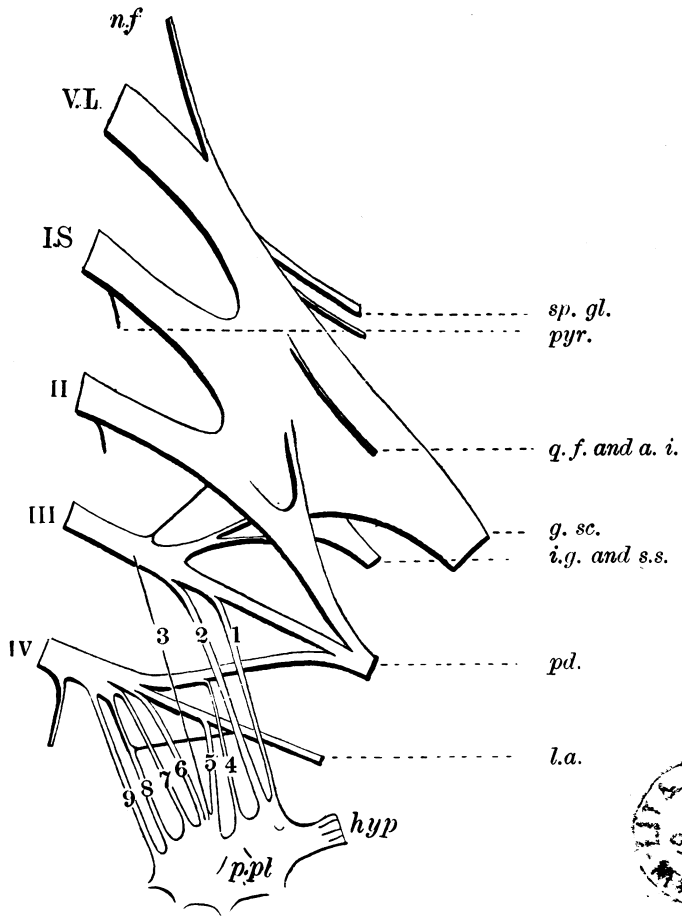


FIG. 2.—Subject, 'M,' left side. (♀ 54 c.m.)



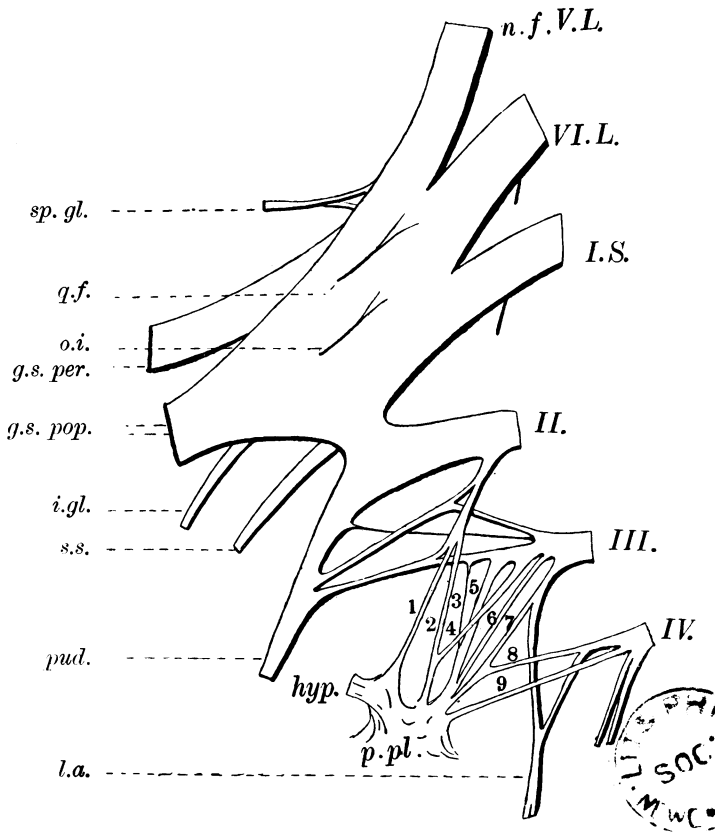


FIG. 3.—Subject, 'G,' right side. (♂ 50 c.m.) XII. Rib absent.

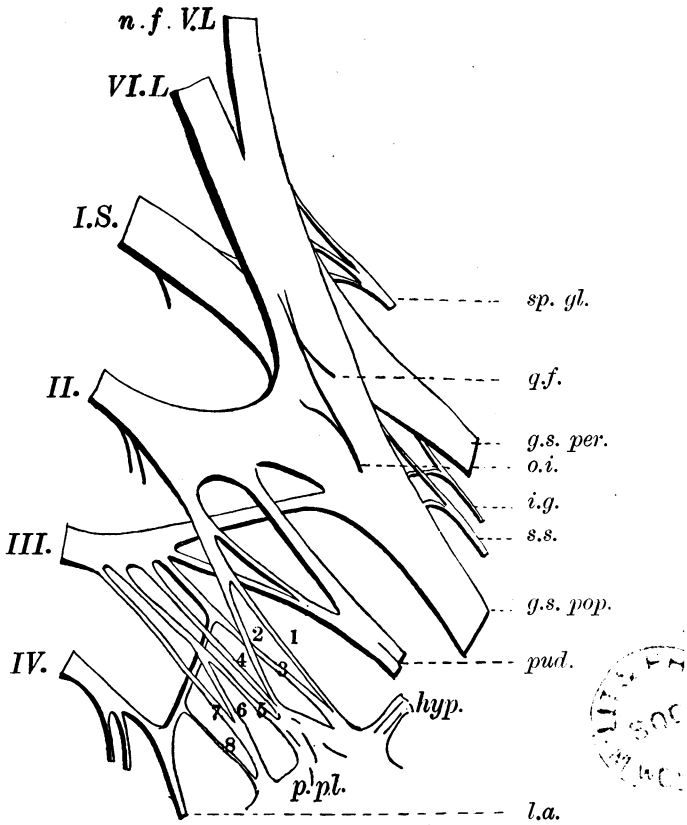


FIG. 4.—Subject, 'G,' left side. ( $\delta$  50 c.m.) XII. Rib absent.

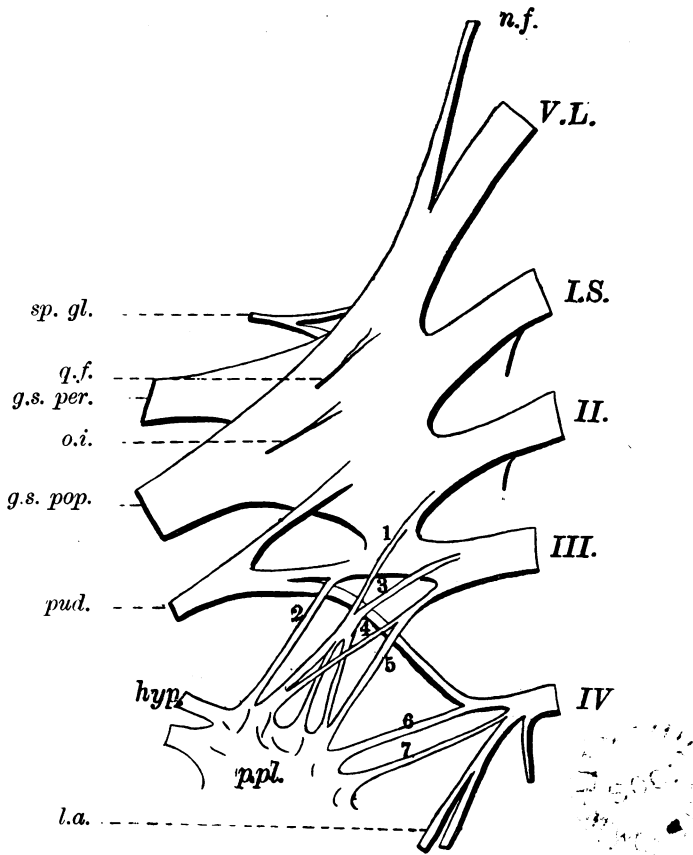


FIG. 5.—Subject, 'H,' right side. (♂ 46 c.m.)

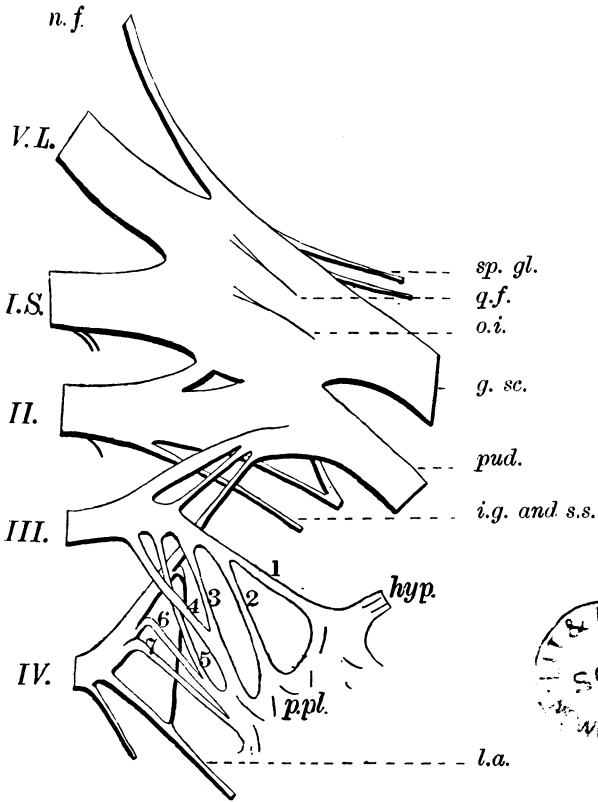


FIG. 6.—Subject, 'H,' left side. (♂ 46 c.m.)

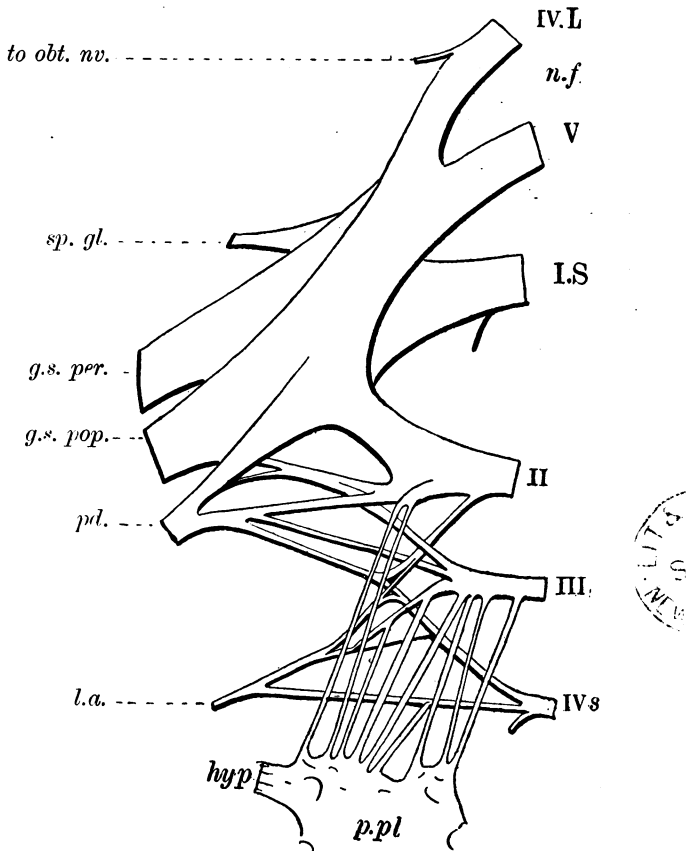


FIG. 7.—Subject 'N,' right side. (♂ 53 c.m.)

*N.B.*—The numbers of the rami are not inserted; they should read from left to right:—No. II., 1 and 2; No. III., 3, 4, 5, 6, 7, and 8; No. IV., 9.

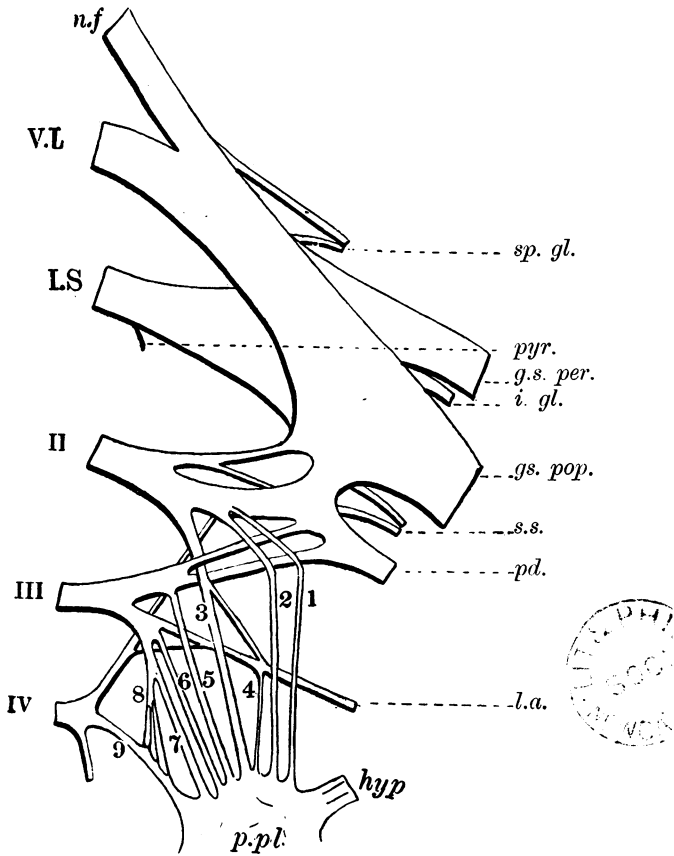


FIG. 8.—Subject, 'N,' left side. (♂ 53 c.m.)

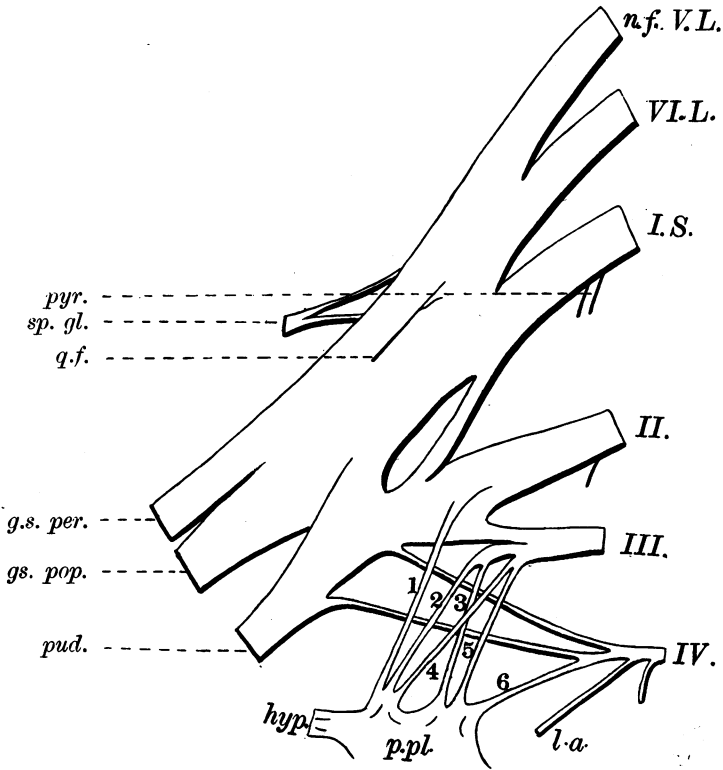


FIG. 9.—Subject, 'K,' right side. (♀ 39 c.m.)

XII. Rib absent.

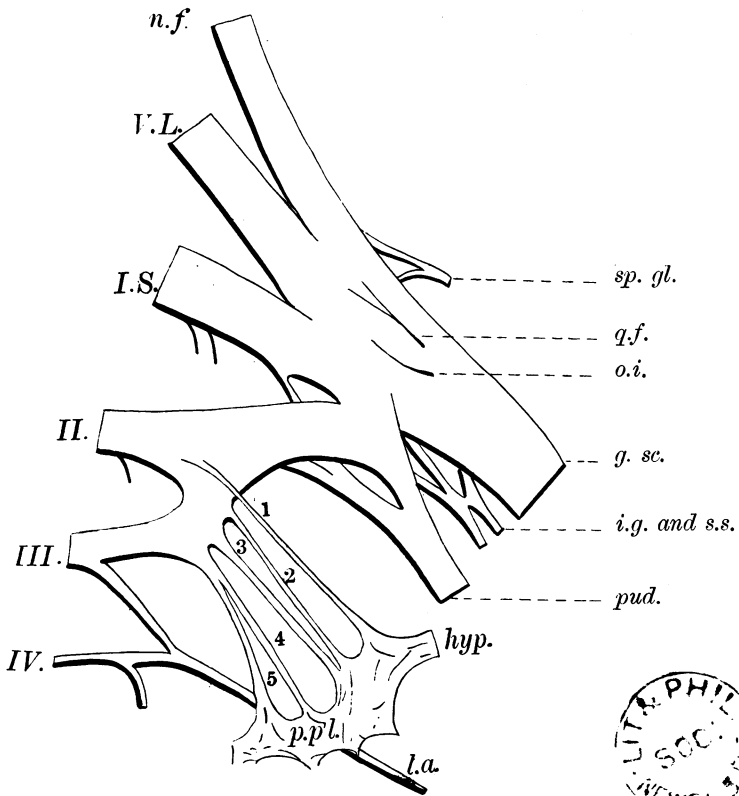


FIG. 10.—Subject, 'K,' left side. (♀ 39 c.m.)  
XII Rib absent.



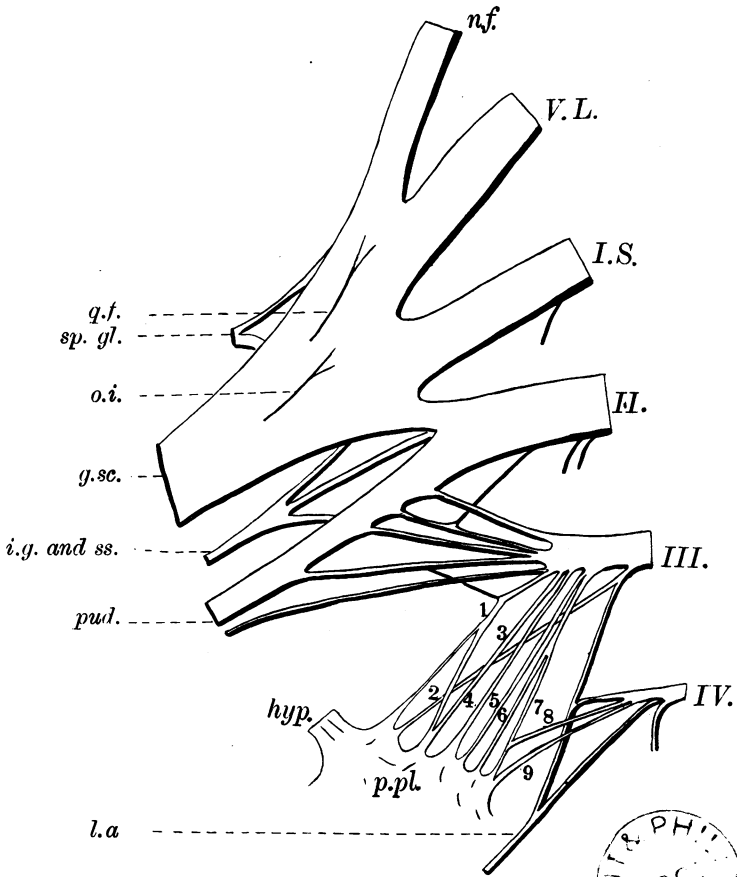


Fig. 11.—Subject, 'L,' right side. (♂ 55 c.m.)

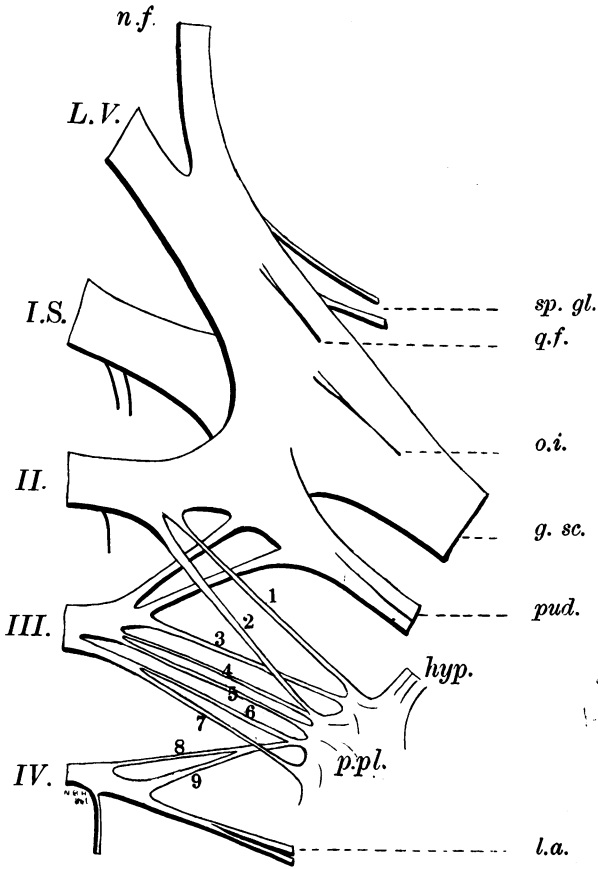


FIG. 12.—Subject, 'L,' left side. (♂ 55 c.m.)

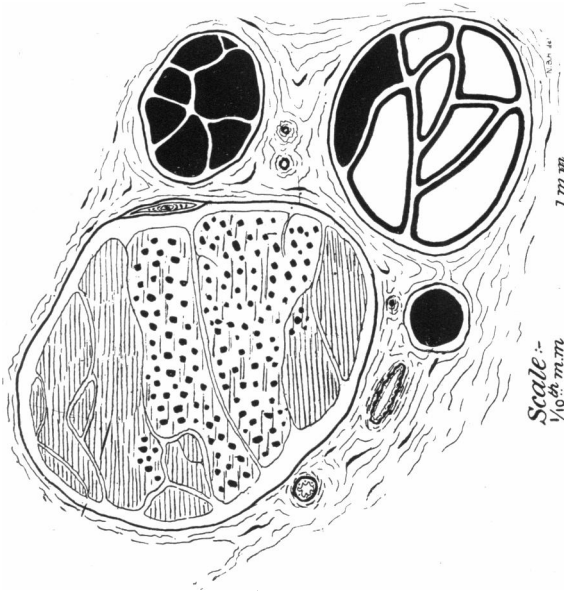


FIG. 13.—Transverse section of the IIIrd Sacral Nerve ('H' right), taken immediately distal to the bulk of the Ganglion. (Drawn with Camera Lucida.)

- Anterior Root :—Fasciculi blackened = Somatic efferent fibres (coarse).  
 Do. darkly outlined = Splanchnic fibres (fine).  
 Posterior Root :—Horizontal shading = Nerve fibres.  
 Dots . . . . . = Ganglion cells.