CHAPTER IV.

LINEAR SERIES—*continued.*

SPINAL NERVES.

THE spinal nerves compose a Meristic Series in many respects similar to that of the vertebræ. As between the vertebræ, so between the spinal nerves, there is differentiation according to the ordinal succession of the members, certain distributions and functions being proper to nerves in certain ordinal positions. The study of the way in which Variation occurs in this series is one of great interest, but unfortunately it is extremely complicated. For while as regards vertebræ the distribution of structural differentiation can be recognized on inspection, in the spinal nerves to obtain a true knowledge of the arrangement in any one case physiological investigation or at least elaborate and special methods of dissection are needed. Though it is therefore impossible to introduce any account which should at all adequately represent the great diversity of possible arrangements, it is nevertheless necessary to refer briefly to the chief results attained by these methods and to the principles which have been detected in the Variation of the nerves. It must of course be foreign to our purposes to examine the many diversities of pattern produced by the divisions and anastomoses of nerve-cords in the formation of plexuses, &c., and we must confine our consideration to cases of Variation in the distribution of differentiation among the spinal nerves, that is to say, in the segmentation of the nervous system in so far as it may be judged from the arrangement of spinal nerves.

Some conception of the magnitude and range of Variation found in single species of Birds may be gained by reference to the beautiful researches of FÜRBRINGER[1]. A table is given by Fürbringer, shewing the number and serial position of the spinal nerves which take part in the formation of the brachial plexus in 67 species of

[1] Fürbringer's memoirs are of such magnitude and completeness that I have felt it to be somewhat of an impertinence to attempt to make selection from them; and it must be remembered that from the isolated and typical cases here given, only a distorted view of the evidence can be gained. As regards this subject, therefore, reference to the original work is especially needed.

64. In the following Table the Roman numbers are the ordinal numbers of the spinal nerves forming the brachial plexus.

The * marks the division between cervical and dorsal regions. In cases where the last cervical nerve is the last of the plexus the fact is not specially indicated.

	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.
Struthio camelus								XVII.	XVIII.	XIX.	XX.	XXI.					
Rhea americana						XV.	XVI.	XVII.	XVIII.								
Apteryx australis				XIII.	XIV.	XV.	XVI.	..... *									
Colymbus arcticus				XIII.	XIV.	XV.	XVI.										
Chroicocephalus ridibundus			XII.	XIII.	XIV.	XV.	XVI.										
,, ,, ...				XIII.	XIV.	XV.	XVI.										
Puffinus obscurus				XIII.	XIV.	XV.	XVI.										
Pelecanus rufescens						XV.	XVI.	XVII.	XVIII.								
Anser cinereus						XV.	XVI.	XVII.	XVIII.	XIX.							
,, ,,							XVI.	XVII.	XVIII.	XIX.							
,, ,,							XVI.	XVII.	XVIII.	XIX. *	XX.						
,, ,,								XVII.	XVIII.	XIX.	XX.						
Cygnus atratus													XXII.	XXIII.	XXIV.	XXV.	XXVI.
Phœnicopterus ruber								XVII.	XVIII.	XIX.	XX.						
Grus canadensis								XVII.	XVIII.	XIX.	XX. *	XXI.					
Charadrius pluvialis			XII.	XIII.	XIV.	XV.	XVI. *	XVII.									
Gallus domesticus				XIII.	XIV.	XV.	XVI.	..... *									
,, ,,				XIII.	XIV.	XV.	XVI.	XVII.									
Opisthocomus cristatus							XVI.	XVII.	XVIII.	XIX.	..... *						
Goura coronata		XI.	XII.	XIII.	XIV.	XV.	..... *										

	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.
Columba livia	X.	XI.	XII.	XIII.	XIV.	XV.											
,, ,,		XI.	XII.	XIII.	XIV.	..... *											
,, ,,		XI.	XII.	XIII.	XIV.	XV.											
,, ,,		XI.	XII.	XIII.	XIV.	XV.	..... *										
,, ,,			XII.	XIII.	XIV.	XV.	..... *										
Uraetos audax			XII.	XIII.	XIV.	XV. *	XVI.										
,, ,,			XII.	XIII.	XIV.	XV.	XVI.										
Buteo vulgaris			XII.	XIII.	XIV.	XV. *	XVI.										
Caprimulgus europæus		XI.	XII.	XIII.	XIV.												
,, ,,			XII.	XIII.	XIV. *	XV.											
Podargus humeralis		XI.	XII.	XIII.	XIV.	..... *											
,, ,,		XI.	XII.	XIII.	XIV.	XV.											
Bucorvus abyssinicus				XIII.	XIV.	XV.	..... *										
Cypselus apus	X.	XI.	XII.	XIII.	XIV.												
Picus medius		XI.	XII.	XIII.	XIV.	XV.											
,, ,,			XII.	XIII.	XIV.	XV.											
Gecinus viridis		XI.	XII.	XIII.	XIV.	XV.											
,, ,,			XII.	XIII.	XIV.	XV.											
Garrulus glandarius		XI.	XII.	XIII.	XIV.	XV.											
,, ,,			XII.	XIII.	XIV.	XV.											
Corvus corone			XII.	XIII.	XIV.	XV.											
Turdus pilaris			XII.	XIII.	XIV.	XV.											

Selected from the table given by FÜRBRINGER, M., *Unters. zur Morph. u. Syst. der Vögel*, 1888, pp. 240 and 241.

(For drawings of the arrangements see the original work.)

Birds investigated by himself. He also gives particulars of the individual variations which were found in certain cases. From this table the following statement is compiled, shewing the most important diversities met with and the instances of individual Variation. In the majority of cases the most posterior spinal nerve of the cervical region was the most posterior nerve of the brachial plexus, but in a certain number of cases it does not join the plexus at all; in some other cases the anterior spinal nerve of the dorsal region also takes part in forming the plexus. As the table shews, each of these plans has been likewise met with as an individual variation.

Fürbringer's table shews 3 as the minimum number of spinal nerves found taking part in the formation of the plexus of any bird (*Bucorvus abyssinicus*): the same number has been found as a minimum by other observers in other birds (v. FÜRBRINGER, p. 242, *note*). The maximum number was 6, found in *Charadrius* and some specimens of *Columba*. The plexus is generally formed by 4 or 5 spinal nerves.

In cases where several individuals were examined, individual variation was generally found, as in *Anser*, *Podargus*, *Picus*, *Gecinus* and *Garrulus*; in these cases the number of spinal nerves which took part in forming the brachial plexus varied between 4 and 5, while in *Columba*, the number even varied between 4 and 6.

Variations also occurred in this respect between the two sides of the body. For example, in a specimen of *Anser cinereus* the plexus was formed on the right side by the nerves XVI, XVII, XVIII and XIX, while on the left side it received a strand from the XXth nerve in addition to these.

As has been stated, the last cervical nerve is generally the last nerve supplying the brachial plexus but deviations from this plan occur in both directions. These deviations may occur as individual variations and they may even be unilateral, owing to the transition between the cervical and dorsal vertebræ being effected at different points on the two sides of the body.

Particulars are given respecting the average proportions of the several roots in the different arrangements, but the arrangement or size of the roots relatively to each other was not found to bear any constant relation either to the systematic position of the bird, or to its size, or to its capacity for flight. It was however generally found that there was a certain relation between the relative size of the roots and the length of the neck in birds with a plexus composed of four roots. In this case the greatest thickness was generally either in or anterior to the middle roots of the plexus in short-necked birds, but posterior to the middle of the plexus in long-necked birds, but even this rule was not at all closely observed and many exceptions occurred. FÜRBRINGER, *l. c.* p. 243.

In Variation in the ordinal positions of the spinal nerves composing the plexus, the pattern of the plexus as newly constituted

commonly bore a resemblance to the original pattern of the plexus, a phenomenon which FÜRBRINGER has called "imitatory Homodynamy" or "Parhomology" of the plexus[1] (*l. c.* p. 245).

Correlation between the constitution of the brachial plexus and the position and number of moveable cervical ribs.

65. **Anser cinereus,** var. **domestica.** Upon this point Fürbringer has made a series of important observations, especially in the Goose, which enabled him to state that there is, within limits, a certain correlation between the composition of the brachial plexus and the development of the ribs of this region. Speaking generally, those individuals in which the plexus was formed in a more anterior position usually shewed a fairly developed cervical rib on the 18th vertebra (*Anser*), and even as in Fig. 12, I, a very short but moveable rib on the 17th vertebra; and in such cases the 19th vertebra generally bore the first true sternal rib. On the other hand, examples with a more posterior development of the brachial plexus shewed not only an entire absence of moveable ribs on the 17th, but even a considerable reduction in the size of the ribs of the 18th and 19th vertebræ, so that these became "transitional" in character, leaving the 20th vertebra as the first vertebra bearing

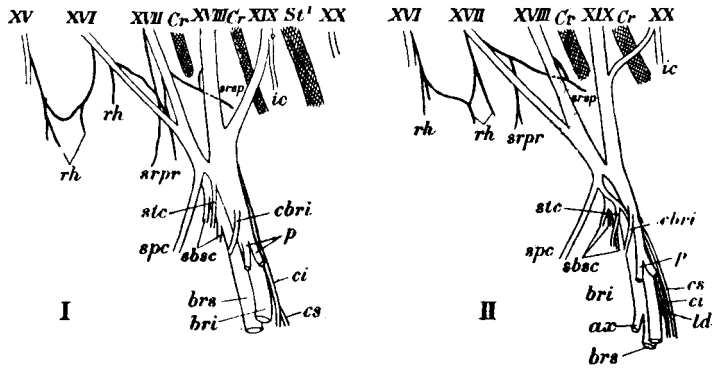

FIG. 12. Diagrams of brachial plexus and cervical ribs in two Geese (*Anser cinereus*, var. *domestica*) after Fürbringer (being his specimens D, *left*, and G, *right*).

I. Case in which the 17th and 18th vertebræ bear cervical ribs and the 19th bears the first sternal rib. II. Case in which the 17th and 18th vertebræ bear cervical ribs, and the 20th bears the first sternal rib.

ax axillaris, *bri* brachialis longus inferior, *brs* brachialis longus superior, *cbri* coraco-brachialis internus, *ci* cutaneus brachii inferior, *cs* cutaneus brachii superior, *ic* intercostals, *ld* latissimus dorsi, *p* pectoralis, *rh* rhomboideus, *sbsc* subscapulares, *srpr* nerves to levator scapulæ and serratus profundus, *srsp* nerves to serratus superficialis, *stc* sterno-coracoideus.

[1] The principle denoted by these expressions is nearly the same as that here expressed in the term Homœosis, which is perhaps more convenient as being a more inclusive expression.

true sternal ribs (Fig. 12, II.). The measurements are given by FÜRBRINGER for 7 specimens, of which those relating to two extreme cases (here figured) are appended.

		Ribs of 17th vert., length in mm.	Ribs of 18th vert., length in mm.	Ribs of 19th vert., length in mm.	Ribs of 20th vert.
I. 23 cm. long	rt.	2·5	20	23·5 (sternal)	(sternal)
	l.	2·75	21	23·75 (sternal)	(sternal)
II. 51 cm. long	rt.	—	7	51 + 13·5 ligt. and cartilage	59 (sternal)
	l.	—	12·5	51 + 15·5 ligt. and cartilage	60 (sternal)

FÜRBRINGER, M., *Morph. Jahrb.*, 1879, v. pp. 386 and 387.

66. By comparison of specimens of the Pigeon, **Columba livia**, var. **domestica,** a similar correlation was found to occur, as shewn in Fig. 13, I. and II. (Fürbringer's specimens A and E).

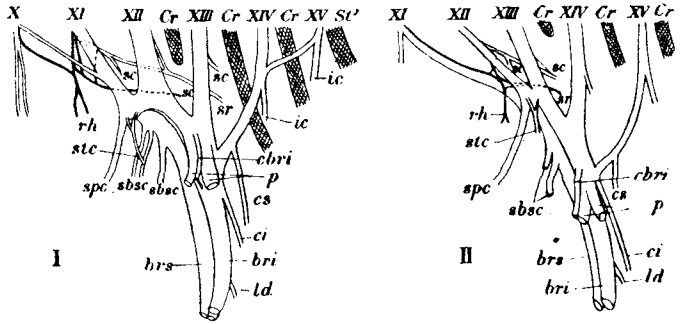

FIG. 13. Diagrams of brachial plexus and cervical ribs in two Pigeons (*C. livia*, var. *domestica*) after Fürbringer.

I. Case in which the 12th, 13th and 14th vertebræ bore cervical ribs. II. Case in which the 13th, 14th and 15th bore cervical ribs. Letters as in Fig. 12.

The measurements of the ribs of these individuals were as follows:

		Ribs of 12th vert., length in mm.	Ribs of 13th vert., length in mm.	Ribs of 14th vert., length in mm.	Ribs of 15th vert.	Ribs of 16th vert.
I.	rt.	—	18	25	1st sternal	2nd sternal
	l.	3	20	26	1st sternal	2nd sternal
II.	rt.	—	3	18	(damaged)	1st sternal
	l.	—	—	18	23	1st sternal

67. The same correlation was established in the case of the Jay **Garrulus glandarius,** but an actual variation in the number of moveable cervical ribs is not recorded in this species (see Fig. 14, I. and II., Fürbringer's specimens A and D). FÜRBRINGER, M., *Morph. Jahrb.*, 1879, v. p. 375.

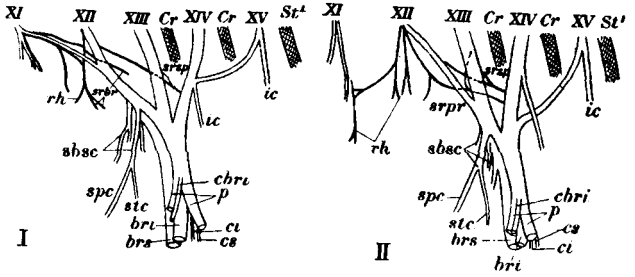

FIG. 14. Diagrams of the cervical ribs and brachial plexus in two Jays (*Garrulus glandarius*) after Fürbringer.

I. Case in which the brachial plexus began from the XIIth nerve, the cervical ribs of 13th and 14th vertebræ being longer than in II, a case in which the XIIIth is the first nerve contributing to the brachial plexus. Letters as in Fig. 12.

The measurements of the two specimens here figured were as follows:

		Ribs of 13th vert., length in mm.	Ribs of 14th vert., length in mm.	Ribs of 15th vert. (with sterno-costal parts), length in mm.
I.	rt.	5	18·5	24·5
	l.	7	20·5	26
II.	rt.	3·5	17·25	22
	l.	3·5	16·5	23

FÜRBRINGER, M., *Morph. Jahrb.*, 1879, v. p. 363.

But though this correlation between the nerves and the ribs is on the whole decided and unequivocal, it should be explicitly stated that it only occurs within certain limits and is not universal, and this statement of correlation is far from covering the whole ground. FÜRBRINGER, *l. c.* p. 387.

BRACHIAL PLEXUS.

*68. **Man and other Mammals.** By minute dissection of the brachial plexus in fifty-five subjects (32 fœtal and 23 adult) HERRINGHAM obtained important evidence as to the parts supplied by the fibres of the several spinal roots forming the plexus, and as to the considerable variation which occurs in respect of this supply. Of the facts thus arrived at, two examples may be quoted

in illustration, concerning the composition of the median and ulnar nerves respectively.

The *median* is formed by two heads from the plexus; into the outer head the VIth and VIIth spinals enter, while the inner is formed by branches of the VIIIth and IXth, sometimes with the addition of some bundles of the VIIth. The presence of fibres from the VIIth depends on whether the anterior branch of the VIIth bifurcates, or goes wholly to the anterior (outer) cord of the plexus. In order to see whether both VIIIth and IXth contribute to the median, twenty-eight dissections were made, fourteen in infants, fourteen in adults. In one fœtus and in one adult no branch from the IXth was found, these being the only exceptions to the rule that both VIIIth and IXth send fibres to the median nerve. The median is then made of the VIth, VIIth, VIIIth and IXth, but these roots do not send to it a constant proportion. The bundle from the VIth varies little, that from the VIIth varies considerably, that from the VIIIth is sometimes equal to, sometimes smaller, and sometimes larger than the bundle from the IXth.

The origin of the *ulnar* nerve was traced in thirty-two cases, fourteen being adults. It was found to arise in four different ways. Most commonly it arose from the VIIIth and IXth: this occurred in twenty-three cases. With the VIIIth and IXth is sometimes combined a strand from the VIIth, as shewn in five cases (four fœtal, one adult). In three fœtal cases it arose from the VIIIth only, and in one fœtal and one adult case from the VIIth and VIIIth. The VIIth is only added to the ulnar in some of those cases in which it gives a branch to the posterior (inner) cord of the plexus. In several cases the branch from the VIIIth was much larger than that from the IXth, but the reverse was never met with.

Evidence similar to the above is given respecting other nerves from the brachial plexus.

From the results of the investigation generally, it appeared that the range of Variation though considerable was not extravagant, and that when parts, usually supplied by some given nerve root, are supplied by some other root, this other root is then either the one anterior or the one posterior to the root from which the supply normally comes. Some muscles seemed to bear definite relations to each other and their nerve supply seemed also "to vary solidly," their nerve supplies remaining the same relatively to each other, though derived from a different root. "The best example of this is in the three muscles which are attached along the inner side of the bicipital groove, the subscapularis, teres major, and latissimus dorsi. The first is usually supplied by the Vth and VIth, the second by the VIth, and the last by the VIIth, and however much they may vary above and below their typical place, they do not change their relations to each other. A similar relation exists between the two supinators and the two radial extensors. These

last are sometimes supplied by the VIth, sometimes by the VIIth, but they are never in any case placed above the supinators. These are always supplied by the VIth alone. The flexor group in the forearm show a similar fixed relation." Herringham concludes that "the nerve roots are not always composed of the same fibres, but that what is in one case the lower bundle of the Vth may be in another the upper bundle of the VIth, and what is now the upper bundle of the VIIIth will at another time be the lower of the VIIth root." Hence the following principle is enuntiated: "*Any given fibre may alter its position relative to the vertebral column, but will maintain its position relative to other fibres.*"

HERRINGHAM, W. P., *Proc. Roy. Soc.*, XLI., 1886 pp. 423, 427, 430, 435.

By physiological methods, SHERRINGTON working chiefly on *Macacus*, but on other animals also, found that this principle substantially holds good for the outflow of fibres throughout considerable *regions* of the cord, but that it is not always applicable to great lengths of the cord, for the brachial plexus may be constituted in a region which is near the head end in comparison with the place of origin in other individuals, while in the same individual the sciatic plexus may be constituted in a region which is for it comparatively far back. No exception to the principle was found in the sense that a given efferent fibre which in one individual is anterior to some other particular fibre is ever in any individual of the same species posterior to it. SHERRINGTON, C. S., *Proc. Roy. Soc.*, LI. 1892, p. 76. This principle of Herringham's is analogous to that which in the much simpler case of Variation in vertebræ was pointed out on p. 107. It was stated that in such Homœotic variation no gaps are left. If a vertebra assumes a cervical character, it is the 1st dorsal, and so on.

*69. The following noteworthy case is described by HERRINGHAM in an infant. It should be borne in mind that to a normal brachial plexus the IVth nerve gives a small communication, the Vth, VIth, VIIth, VIIIth and IXth give large cords, while the Xth (or IInd dorsal) gives a minute fibre only. In this abnormal specimen, on the *left* side the part from the Xth was as large as that from the IXth, and this was as large as the VIIIth, whereas the natural proportion of VIIIth to IXth is about 2 to 1. The musculo-cutaneous received from the VIIth, instead of from the Vth and VIth only as more commonly found; the median received no VIth (*v. supra*); the teres major was supplied by the VIIth alone, instead of by the VIth; the circumflex received from the VIIth, instead of Vth and VIth alone as seen in 43 cases without any other exception; the musculo-spiral was formed by the VIIth, VIIIth and IXth, instead of by the VIth, VIIth and VIIIth (and sometimes even Vth); the deep branch in the hand received from both VIIIth

and IXth (instead of VIIIth alone, as seen in five cases out of six). But though in all these respects the nerve-supply of the plexus was in ordinal position posterior to the normal, nevertheless the IVth sent a communication to the Vth (as it does normally) and the suprascapular and subscapular were given off normally. Here, then, the supply to the plexus began at the normal place, though it extended further back than it normally does. On the *right* side the branch from the Xth was slightly bigger than usual, but otherwise the only abnormality noted was that the IXth sent a branch to the musculo-spiral. HERRINGHAM, W. P., *Proc. Roy. Soc.*, 1886, XLI. p. 435. In view of FÜRBRINGER'S evidence (see Nos. 65 and 67), it might be expected that the first rib would be reduced in correlation with the irregular forward Homœosis of the nerves. In reply however to a question on the subject, Dr Herringham has kindly informed me that no abnormality in the ribs was seen, but that this point was not specially considered.

Compare also LANE'S case, No. 24, in which similarly a large branch from the Xth joined the plexus on the right side and the first rib was rudimentary, both structures thus shewing a correlated forward Homœosis.

LUMBO-SACRAL PLEXUS.

*70. By physiological methods SHERRINGTON found that the supply to the lumbo-sacral plexus varied considerably with regard to its origin from the spinal nerves. This was seen in *Macacus*, in the Cat and in the Frog. In none of these animals was any one arrangement found sufficiently often to justify its selection as a "normal" type. In each case it was found convenient to divide the different forms of arrangement into two classes, the one in which the supply to the plexus was in ordinal position more anterior ("pre-axial," Sherrington), the other being more posterior ("post-axial," Sherrington). Particulars respecting the distribution of the several nerves and the movements resulting from their stimulation in the two classes, are given in detail (q. v.). In *Macacus*, 31 individuals belonged to the more anterior class, and 21 to the more posterior. In the Cat the number of individuals in the two classes was 22 and 39 respectively. It is stated generally that

> "The distribution of the peripheral nerve-trunks is not obviously different, whether, by its root-formation the plexus belong to the pre-axial class, or to the post-axial. The peripheral nerve-trunks are, as regards their muscles, relatively stable in comparison with the spinal roots. When the innervation of the limb-muscles is of the pre-axial class, so also is that of the anus, vagina and bladder; and conversely." SHERRINGTON, C. S., *Proc. Roy. Soc.*, 1892, LI. pp. 70—76.

71. **Primates.** Since in examining the facts of Variation we are seeking for evidence as to the modes in which specific differences

originate, allusion may therefore be made to some facts of normal structure in differing forms in illustration of the nature of such differences, and for comparison with the differences which are seen to occur by Variation. The arrangement of the lumbo-sacral plexus in the Primates well exemplifies some of these points. In Man, Chimpanzee and Gorilla the 1st sacral vertebra is the 25th; in the Orang it is the 26th; in the Baboons, e.g. *Macacus inuus* (= *Inuus pithecus* Is. Geoff., the Barbary Ape) it is the 27th. Now, as Rosenberg says, seeing that in Man the sacral plexus receives one whole præ-sacral root, the XXVth, and part of the XXIVth, it might be supposed that this plexus in the Orang would receive *two* whole præ-sacral roots and part of a third, or that in *Macacus* it would receive *three* præ-sacral roots and part of a fourth. But, as a matter of fact, in each of these forms, Chimpanzee, Orang and *Macacus*, according to Rosenberg, only one whole præ-sacral root and part of the next above it enter the sacral plexus, just as in Man, though the ordinal positions of the nerve-roots are different.

The Chimpanzee, however, which Rosenberg examined, was the specimen described (No. 34), having the 25th as a transitional lumbo-sacral vertebra, and rudimentary ribs on the 21st. In this specimen the præ-sacral nerves received by the sacral plexus were the XXVIth and part of the XXVth, thus bearing the same ordinal relations to the sacrum that the nerves of the lumbo-sacral cord do in the other forms and in Man, though each is ordinally one lower in the whole series than it is in Man. The same was true of the spinal roots composing the obturator and crural. ROSENBERG, E., *Morph. Jahrb.*, 1. 1876, pp. 148, 149 and *Tables*, note 19.

This case is interesting as an example of forward Homœosis in the vertebræ associated with forward Homœosis in the sacral plexus. When compared with the following case of a Chimpanzee[1] having normal lumbo-sacral vertebræ, several discrepancies will be seen beyond those which can be accounted for by the single change of one in the ordinal position of the roots. No doubt for the larger nerves Rosenberg's account is correct, but as he states that the specimen was so badly preserved that the nerves could not be satisfactorily traced, it is possible that some of the branches may have been missed. However this may be, the specimen dissected by Champneys had important features of difference, notably that the sacral plexus received from the XXIInd spinal, while the highest recorded as entering it in Rosenberg's case was the XXVth, a greater difference than can be accounted for on the simple hypothesis of a change of one place throughout. Though, speaking generally, Rosenberg is right in saying that the evidence of the normal condition in *Macacus* and Orang as compared with each other and with Man

[1] CHAMPNEYS, F., *Journ. Anat. Phys.*, Ser. 2, v. 1872, p. 176.

suggests that the variation of the vertebral regions goes hand in hand with that of the plexus, and though a comparison between Rosenberg's abnormal Chimpanzee with that dissected by Champneys largely bears out this suggestion, yet it is also clear that this correlation is not a precise one, as indeed has already appeared in several instances.

In giving the compositions of the several nerves of the lumbo-sacral plexus in Man and Chimpanzee, I have given the numbers of the nerves in the *whole* series for simplicity of comparison. It will be remembered that a Chimpanzee has one pair of ribs more than Man, the XXIst nerve is the 1st lumbar in Man, but is the 13th dorsal in Chimpanzee, the XXVIth nerve being the 1st sacral in both forms. The table given shews, as Champneys says, that the *general* arrangement of the nerves of the lower limb and lumbar and sacral plexuses was in Chimpanzee very similar to that in Man, but that the nerves are very differently composed.

	MAN.		CHIMPANZEE.
Ilio-hypogastric } Ilio-inguinal }	XXI.	.....	XXI.
Genito-crural	XXI.—XXII.	.....	XXI.
External cutaneous	XXII. XXIII.	.....	XXI., XXII.
Obturator	XXIII. XXIV.	.....	XXI.—XXIII.
Anterior crural	XXII.—XXIV.	.....	XXI.—XXIV.
Superior gluteal	XXIV.—XXVI.	.....	XXIV.—XXVI.
Sacral plexus	XXIV.—XXIX.	.....	XXII.—XXVII.
Small sciatic	XXIV.—XXIX.	.....	XXIV.—XXVI.

(From CHAMPNEYS, *l.c.* p. 210.)

The origin of the nerves is therefore in several cases lower in Man than in the Chimpanzee, although in the absence of ribs on the 20th vertebra Man shews a character which, as compared with the presence of ribs in this position in the Chimpanzee represents a backward Homœosis.

Man. With the foregoing, compare the case mentioned above (No. 32) in which two entire lumbar nerves joined the sacral plexus in a human subject having no ribs on the 19th vertebra, &c. STRUTHERS, *J. Anat. Phys.*, 1875, p. 72 and p. 29.

72. For information as to the variations of the lumbo-sacral plexus in the Primates see also ROSENBERG, *Morph. Jahrb.*, I. 1876, p. 147 *et seqq.*; and as to cases in Primates and in other vertebrates compare VON JHERING, *Das peripherische Nervensystem der Wirbelthiere, &c.*, Leipzig, 1878. Of these, two cases of partial backward Homœosis in the lumbo-sacral plexus of the Dog are perhaps noteworthy, as being represented and described in greater detail than many of von Jhering's cases. In *one* of these the rib of the 13th dorsal (20th vertebra) was not developed, this vertebra being formed as a lumbar and thus itself shewing a backward Homœosis in correlation to that of the nerves

(VON JHERING, *l. c.* p. 182, pl. IV. fig. 2). Descriptions and diagrams of similar cases are given throughout the work, but as some of them represent specimens described by others (e.g. STRUTHERS and ROSENBERG) originally without diagrams, it is difficult to know how far the accounts given are schematic. For this reason reference to the original work must be made.

*73. **Bradypodidæ.** *Brachial plexus.* As examples of normal differences the Sloths are especially interesting, but unfortunately an extended investigation of the nerves in several individuals has not been made. The results found by SOLGER relate to one specimen of *B. tridactylus* and one of *C. didactylus.* The latter was a perfect specimen, but the former had been partially dissected and the details of the nerves were largely imperfect. The *Cholœpus* was a specimen with seven cervicals, and the *Bradypus* had nine, the last bearing rudi-

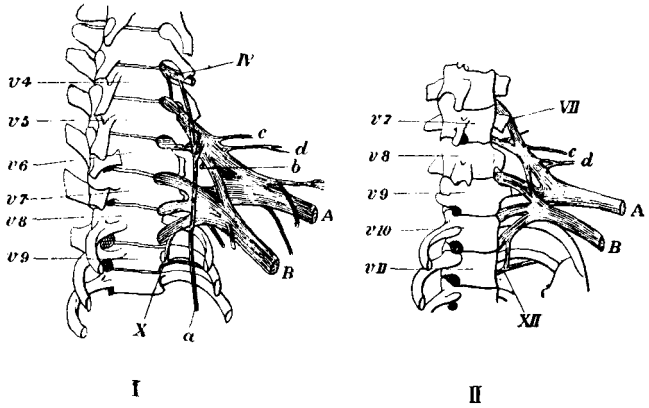

FIG. 15. Diagrams shewing the composition of the brachial plexus in I. a *Cholœpus*, II. a *Bradypus*. v^1—v^{11}, the vertebræ. IV, VII, X, XII, fourth, seventh, tenth and twelfth cervical nerves. *A*, dorsal cord. *B*, ventral cord. *a*, phrenic. *b*, dorsalis scapulæ. *c*, suprascapular. *d*, subscapular.

mentary ribs. As the figure shews (Fig. 15), there was a close but not a perfect resemblance between the composition of the plexus in the two cases, that of *Bradypus* being in nearly each case two roots lower than that in *Cholœpus.* In the latter the IVth nerve gave a branch to the Vth, but whether in *Bradypus* the VIth gave a branch to the VIIth was not determined with certainty owing to the condition of the specimen. [For details see original paper] SOLGER, B., *Morph. Jahrb.*, 1875, I. p. 199, Pl. VI.

One more case may be given in illustration of the kind of difference which normal forms may present.

74. **Pipa** (the Surinam Toad). In the majority of the Batrachia, the most anterior pair of spinal nerves leaves the vertebral column between the first and second vertebræ, no sub-occipital being present. The

second pair leaves between the second and third vertebræ, and the third pair leaves between the third and fourth vertebræ. The brachial plexus is formed by the whole of the second pair together with parts of the first and third pairs. (The details of the arrangement are complicated and vary greatly in different forms.) In *Pipa* a different arrangement exists. The most anterior pair of nerves leaves the spinal column by *perforating* the first vertebra, and the pair which leaves between the first and second vertebræ is therefore ordinally the *second* pair of spinal nerves in this form; the pair which leaves between the second and third vertebræ is the *third*, and so on. The brachial plexus is made up of the whole of the second nerve, nearly the whole of the third nerve and of a branch of the first.

If then it were to be supposed that the pair of nerves which leaves the column between the first and second vertebræ in *Pipa* is homologous with the pair of nerves which leaves in the same place in *Rana*, &c., it is clear that between the skull and the 2nd vertebra of *Pipa*, there is an extra pair of nerves not found in *Rana*. The number of free vertebræ in *Pipa* is however less than in *Rana*. For in the former there are only seven of these, making with the united sacral vertebra and urostyle eight pieces in all; but in *Rana* there are eight præsacrals, one sacral, and counting the urostyle, ten pieces in all. In *Rana* only one spinal nerve, the 10th, leaves the urostyle, while in *Pipa* two pairs, the 9th and 10th, pass out through the terminal piece of the vertebral column, suggesting that the diminution in the number of vertebræ is due to the absence of separation between the 9th vertebra and the urostyle. The whole number of spinal nerves is therefore the same in both *Rana* and *Pipa*, but in the latter the 1st pair perforate the 1st vertebra in addition to the 2nd pair which pass out between the 1st and 2nd vertebræ. FÜRBRINGER[1], M., *Jen. Zt.*, 1874, VIII. p. 181 and *Note*, Pl. VII. fig. 37; also *Jen. Zt.*, 1873, VII. Pl. XIV. figs. 5 and 6.

It was suggested by STANNIUS (*Lehrb. d. vergl. Anat.*, p. 130, *Note*) that perhaps the 1st vertebra of *Pipa* represents two coalesced vertebræ, but in an anatomical examination of two specimens of *Pipa*, Fürbringer (*l. c.* 1874, p. 180), found no confirmation of this suggestion, and developmental evidence also went to shew that no such fusion occurs in the ontogeny at least[2]. KÖLLIKER, A., *Verh. phys.-med. Ges. Würzburg*, 1860, X. p. 236.

As Fürbringer says there is no satisfactory way of bringing this case of *Pipa* into accord with the condition seen in *Rana*. In the Urodela there is of course a suboccipital nerve between the skull and the 1st vertebra which is not present in *Rana*, and some resemblance to *Pipa* is thus suggested; but in the Urodela the 1st spinal does not actually

[1] Compare VON JHERING, H., *Morph. Jahrb.*, 1880, VI. p. 297. The statement made by von Jhering that the nerves of *Pipa and Rana* correspond nerve for nerve, though in different positions relative to the vertebræ, if established would be important; but from the want of detailed description it is not clear whether this conclusion was arrived at by actual dissection.

[2] This is questioned by ADOLPHI, *Morph. Jahrb.*, XIX. 1892, p. 315, *note*. The same paper contains much important matter bearing on the variation of the nerves of Amphibia. I regret that this paper did not appear in time to enable me to incorporate the facts it contains.

anastomose with the plexus, though it gives off the superior thoracic which in both *Rana* and *Pipa* comes off at a point peripheral to the formation of the plexus (Fürbringer).

If the two spinal nerves which come out of the urostyle in *Pipa* may be taken to shew that this bone contains $n+2$ vertebræ while the single pair in *Rana* shews the urostyle to consist of $n+1$, there is in *Pipa* (as compared with *Rana*), a diminution of one in the total number of vertebræ, together with a backward Homœosis, which is seen in the fact that the 8th vertebra bears the pelvic girdle. Turning now to the nervous system, the fact that the last spinal nerves to join the brachial plexus in *Pipa* are the IIIrd, while in *Rana* they are the IVth, is again an evidence of backward Homœosis. But if this process were completely carried out, the pair of nerves which in *Pipa* pass out through the 1st vertebra should pass out between this vertebra and the skull, i.e. in the position of the suboccipital of the Urodela. Beyond this analysis cannot be carried, and this case is a good illustration of the fact that the hypothesis of an individual homology between the segments does not satisfy all the conditions of the problem.

Relation between the ordinal position of spinal nerves and their distribution to the limbs.

This subject is introduced partly because it further illustrates the nature of the relations which the spinal nerves maintain towards each other, and thus bears indirectly on the phenomena of their Variation; but chiefly because it presents a view of some of the complexities which arise in the apportionment of organs centrally disposed in Meristic Series, to the parts of peripheral appendages having no clear or co-incident relation to the primary or fundamental segmentation of the body. The facts have thus a value as furnishing a kind of commentary on the nature of Meristic Repetitions in vertebrates. In any attempt to interpret or comprehend Meristic Repetition as a whole, they must be taken into account.

The principles of the distribution of the spinal nerves *to the muscles of the fore-limb* have been thus enuntiated by HERRINGHAM.

1. "Of two muscles, or of two parts of a muscle, that which is nearer the head-end of the body tends to be supplied by the higher, that which is nearer the tail-end by the lower nerve.

2. "Of two muscles, that which is nearer the long axis of the body tends to be supplied by the higher, that which is nearer the periphery by the lower nerve.

3. "Of two muscles, that which is nearer the surface tends to be supplied by the higher, that which is further from it by the lower nerve." HERRINGHAM, W. P., *Proc. Roy. Soc.*, XLI. 1886, p. 437.

Details are given shewing the manner in which the innervation of the muscles in Man bears out these principles.

FORGUE and LANNEGRACE[1], who worked with dogs and monkeys by physiological methods, arrived at conclusions identical with those which Herringham came to by human dissection.

[1] *Distrib. des racines motrices*, &c., Montpellier, 1883, p. 45 [quoted from Herringham: not seen, W. B.]; also *Comptes Rendus*, 1884, CXVIII. p. 687.

As regards *the sensory nerves in the fore-limb*, the following principles were similarly established by dissection in Man.

1. "Of two spots on the skin, that which is nearer the pre-axial border tends to be supplied by the higher nerve.

2. "Of two spots in the pre-axial area the lower tends to be supplied by the lower nerve, and of two spots in the post-axial area the lower tends to be supplied by the higher nerve."

"Thus, if the limb be seen from the front, the two highest nerves on the outer and inner sides respectively are the IVth and Xth. Lower than these the Vth and VIth take the outer, the IXth and Xth the inner side. Below the elbow the VIth alone takes the outer, and the IXth alone the inner. In the hand, while the VIth and IXth continue their positions, the VIIth and VIIIth for the first time join in the supply." Particulars from which this general statement is made are given. HERRINGHAM, *l.c.* p. 439.

According to subsequent investigations of SHERRINGTON'S on the *hind-limb*, the innervation of the muscles of the posterior aspect of the thigh and leg do *not* follow the third of Herringham's principles, for in their case the deep layer of muscles is innervated by roots anterior to those which innervate the superficial muscles. The same experiments also, though clearly shewing that the nerve-supply of the *skin* of the hallux is anterior to that of the 5th digit, gave only equivocal evidence that the same was true of the musculatures of these two digits; and in the thigh the gracilis is not supplied before the vastus externus, whose relation is rather that of ventral to dorsal than of anterior to posterior. SHERRINGTON, C. S., *Proc. Roy. Soc.*, 1892, LI. p. 77.

RECAPITULATION.

Some features in the Meristic Variation of the spinal nerves, as illustrated by the foregoing evidence, may be briefly summarized.

In the first place, as might be anticipated from the compound nature of a spinal nerve, when Homœotic Variation takes place, it does not commonly occur by the transformation of entire nerves, but rather by change in the distribution and functions of parts of nerves. In this respect, therefore, there is a difference between Homœosis in spinal nerves and that in vertebræ, for in the latter, Homœosis is often complete.

A rough illustration may make this more clear.

Just as in making up the chapters of a book into volumes, whole chapters may be put into one volume or into the next, and the following chapters renumbered, so it may be with the Variation of vertebræ, for these may belong wholly to one region of the spine or to another. But the nerves are like chapters made up of sections; particular sections or groups of sections may come in an earlier chapter or in a subsequent one, and the places of those that have been moved on may be filled up consecutively, but it seldom happens that whole chapters are renumbered. Nevertheless it is clear from such a case as that of *Bradypus* and *Cholœpus*, on the

hypothesis that both forms are descended from a common ancestor, that such changes and renumbering of whole nerves must have happened, though there is evidence to shew that this may happen piecemeal, as in cases given.

Of course in speaking of such changes among the vertebræ it will not be forgotten that partial changes occur too, but there is still greater Discontinuity in their case than in that of the nerves.

But that there is Discontinuity in the case of nerves also is clear; for a given fibre, supplying a given muscle, must leave the spinal cord either by one foramen and one spinal nerve, or by another. Conversely the *n*th motor nerve must supply either one muscle or another, and the transition between the two, however finely it may be subdivided, must ultimately be discontinuous in the case of individual fibres. It would be interesting to know to what extent fibres vary in bundles, but this can hardly be determined.

There is, however, some evidence that the group of fibres supplying a limb does to some extent vary up and down the series as a group, though much rearrangement may occur also within the limits of the group itself.

Lastly, there is important evidence that Variation in other parts *may be* correlated with change in the ordinal positions at which nerves with given distributions emerge from the spinal cord. With Variation in the ordinal positions at which the nerves come out, change in other parts, notably in the ribs, *may* happen too; so that we may say that in a sense there may be, at least within the limits of single species (see cases Nos. 24, 65 and 71), a correlation between the apportionment of their functions among the nerves and the contour of the body, both changing together, the ribs rising and falling with the rise and fall of the brachial plexus. The nerves do not merely come out through the foramina like stitches through the welt of a shoe, the shape of the shoe remaining the same wherever the threads pass out. The arrangement is, rather, like that of the strings of such an instrument as a harp or piano, in which there is a correlation between the curves of the frame and the positions of the several notes: so long as the frame is the same, the strings cannot be moved up or down, the instrument still retaining the same compass and the same number of notes.