ON THE SUTURE OF SEPARATE NERVE BUNDLES IN A NERVE TRUNK AND ON INTERNAL NERVE PLEXUSES. BY J. N. LANGLEY, F.R.S. AND M. HASHIMOTO, M.D.

(*From the Physiological Laboratory, Cambridge.*)

THE completeness of recovery of sensation and muscular control after nerve suture depends upon a number of factors. Amongst the factors which delay or prevent complete recovery are the following:

1. A certain number of the fibres of the central end of the nerve, as they grow out, pass into connective tissue instead of into the nerve fibres of the peripheral end and fail to make nervous connexion. The loss of central connexion so caused is to some extent compensated by the division of the nerve fibres which pass into the peripheral end.

2. Some fibres of the central end though they grow into the peripheral end are unable to make functional nerve endings. This occurs when efferent fibres grow into afferent, or afferent into efferent. It almost certainly occurs to some extent also in cross union of afferent fibres of cutaneous sensation and afferent fibres of deep sensation, and may also occur in cross union of the fibres serving for the various forms of each of these classes of sensation.

Evidence of a growth of efferent fibres of a muscle nerve down a purely sensory nerve (muscle branch of crural and internal saphena) was given by Langley and Anderson(3); who traced such fibres a distance of 7 cm. down the nerve. They suggested (*op. cit.* p. 380) that afferent fibres might grow down efferent fibres and form afferent nerve endings which from character and position were incapable of transmitting impulses to muscle, gland or motor nerve cells. Further evidence of the growth of efferent fibres down an afferent nerve (posterior interosseus and radial) was given by Osborne and Kilvington(5). Boeke(10) after union of the hypoglossal with the lingual has traced fibres down the lingual branching under and between the epithelial cells of the tongue.

3. Some fibres make functional nerve endings but the central connexion of these fibres is different from that existing before the nerve lesion so that an adjustment of impulses in the central nervous system must occur in order to allow of co-ordinated movement. The change in

the central connexion of the peripheral units is spoken of as a distortion of the nerve pattern, and the adjustment of impulses in the nerve centres is commonly spoken of as the re-education of the nerve centres. The re-adjustment of the nerve centres is probably concerned in the main with the afferent nerve impulses and there can be little doubt that it must vary in degree with the different forms of afferent impulses. As Osborne and Kilvington(7) have pointed out, the slower return of "epicritic" than of "protopathic" sensation (Head and Rivers) may reasonably be accounted for on the view that a longer time is required for central adjustment in the former case.

Re-adjustment of the nerve centres is commonly spoken of as if it were only necessary when the central end of one nerve trunk is joined to the peripheral end of another, for example in crossed union of the flexors and extensors, but it is obvious that it is necessary to a greater or less extent after suture of any nerve trunk, since there is always some spreading out of the central fibres into new areas. The crossing of the nerve for the extensor digitorum communis with that for the tibialis anticus—both of which are in the same nerve trunk—would cause at least as much disarrangement of co-ordinate action as crossing the extensor and flexor nerves of the limb, which are in different nerve trunks. Since, as Sherrington has shown, the reciprocal action of antagonistic muscles is regulated mainly by the afferent fibres of the muscles, total crossing of flexor and extensor nerves may involve relatively little central re-adjustment as regards simple flexion and extension movements.

The slow return of the more complicated movements after nerve suture shows, we think, that central re-adjustment is a cause of delay in recovery, *i.e.* that it does not occur simultaneously with the formation of new nerve endings. There are, however, no satisfactory data as to the extent of the delay. As we have said above re-adjustment is required whether a nerve trunk is sutured or cross sutured, and experiments have only been made on nerve trunks. As regards these no certain difference has been noted in the time of recovery of the relatively simple movements of walking and running, but more attention has been paid to cross suture than to suture. A few observations of the time of recovery of fairly complex movements on cross suture have been made by Kennedy(2), who gives also an account of earlier observations, and by Osborne and Kilvington(8), but we do not know of any experiments on simple suture with which they can be strictly compared. Kennedy(2) compares two cases of cross suture with one of suture, but the latter was only observed for about three months. The early stages of recovery, it is to be noted, are difficult to interpret, since some degree of movement must occur as soon as nerve fibres have made functional connexion with the muscle, and crossed fibres soon make some connexion. Kennedy in a recent interesting paper (11) comes to the conclusion that extensor and flexor muscles recover earlier if joined to extensor and flexor nerves respectively. He leaves it an open question whether central adjustment has anything to do with this. But in any case, if the conclusion is justified, it supports the view that distortion of nerve pattern is a cause of delay in recovery.

Kennedy(1) has stated that twisting a nerve has no appreciable effect on the rate of recovery. In three experiments on dogs, the sciatic was cut at the trochanter, twisted 180° and sutured; this it will be noticed is nearly equivalent to cross suture of the peroneal and tibial nerves. Recovery was said to begin on the seventh day and to be practically complete on the 14th, 19th, and 21st day respectively. Although in favourable circumstances a rapid partial recovery may take place, we are unable to accept the rates given in these experiments, and it may be noted that Kennedy in his later papers has laid considerable stress on the difficulty of interpreting the symptoms following section of the sciatic in the dog. As we shall show below, the effect of twisting a nerve depends on the region of the nerve operated on.

4. A further cause of delay in complete recovery, and perhaps of prevention of it, is that single fibres may divide and the branches pass to different muscles in the case of efferent fibres, and to afferent nerve endings in different regions in the case of afferent nerve fibres. In each case there must be disturbance of co-ordination, and, far as can be seen, the disturbance cannot be remedied except by degeneration of the neurone.

The chief evidence of the foregoing statement as regards efferent fibres is the occurrence of an axon reflex in regeneration, and the not infrequent formation of more than one peripheral fibre by the central end of a cut nerve fibre. Instances of an axon reflex have been given by Langley and Anderson(3), after union of the central end of a branch of the crural nerve running to muscles with the internal saphenous nerve. The question has been dealt with more fully by Kilvington(4) and Osborne and Kilvington (5, 6). They experimented on the union of (*a*) the internal popliteal nerve with the peripheral ends of the internal and external popliteal nerves and (*b*) the musculo-spiral nerve with the peripheral ends of the radial and posterior interosseus nerves.

In the cases so far mentioned there was more or less cross suture of nerve trunks. Osborne and Kilvington(6, 7) also give cases in which an axon reflex was obtained from the external popliteal after simple suture of the sciatic, and from the radial after suture of the musculo-spiral nerve. The following experiment shows that an axon reflex may be obtained after suture of the peroneal nerve. In a cat, we cut and sutured the peroneal nerve where it crosses over the gastrocnemius muscle; 2 months later the nerve was cut above the point of suture, the musculo-cutaneous nerve cut at the ankle and its central end stimulated; the stimulation caused contraction in the upper end of the tibialis anticus muscle. Stimulation of the peripheral end of the nerve had as usual no effect. In fact, whenever a nerve which contains fibres for more than one muscle is sutured, there is a risk of some dividing fibres running to more than one muscle. There can be no doubt that there is also a branching of afferent nerve fibres like that which occurs in efferent nerves.

It must be noticed that since in regeneration the numbers of fibres which divide and supply two muscles is small relatively to those which run wholly to one muscle, the existence of the former cannot prevent movement but only causes a certain amount of resistance to it.

The foregoing causes of delay in complete recovery after nerve suture are generally recognised, though there is very little agreement as to the absolute or relative degree of importance to be attached to them. They fall under two heads; first lessening of central connexion, which may be due either to nerve fibres growing into connective tissue, or to a crossing between afferent and efferent nerves; secondly, distortion of nerve pattern, due to nerve fibres forming peripheral connexions different from the normal. The two may be included in the terms "disturbance of nerve pattern."

Since most nerve trunks contain efferent and afferent fibres for several muscles and nerve fibres for the skin, it is obvious that on suturing them the chances of lessening of central connexion and of distortion of nerve pattern are considerable.

Further in the peripheral part of nerve trunks the nerves for the different muscles have become arranged to a greater or less extent in different bundles, so that in suture there is a chance of nearly all the fibres originally passing to one muscle growing down the nerve to a different muscle and to an interchange of muscle and cutaneous nerves. The following experiment on a cat may be given in illustration of the latter points. In it, and in other experiments, chloroform was first given, then A.C.E. by tracheal tube and usually urethane.

The peroneal nerve was exposed a little above the spot where it dips under a slip of the gastrocnemius muscle, *i.e.* before its division into anterior tibial and musculo-cutaneous nerves. It consisted to the eye of seven small bundles arranged side by side as in Fig. 1 *a*; these were isolated, tied, and the peripheral ends stimulated, after isolating the extensor muscles of the leg. The isolation of the nerve filaments in this and in other experiments was effected by picking up the epineurium with very fine forceps and cutting it through with sharp small scissors meeting well at the points. Each nerve bundle was found to supply a separate region. We may take the bundles from the outer to the inner border. No. 1 caused contraction of the upper part of the tibialis anticus muscle; No. 2 of the extensor digitorum communis, No. 3 of the lower part of the tibialis anticus, No. 4 of the peroneus quinti digiti and the peroneus brevis; Nos. 5 and 6 had no muscular effect on the leg or foot, *i.e.* they were purely afferent; No. 7 which ran obliquely over the lateral bundles caused contraction of the peroneus longus. In Fig. 1 *b* we give a diagrammatic sketch of the dissection of the peroneal nerve bundles in another cat, starting somewhat peripherally of the region stimulated in the experiment. The parts of the nerve are separated from one another and the n. peroneus longus placed parallel with the cutaneous bundle. The nerve for the peroneus quinti dig. and per. brevis was in this case on the antero-external side of the cutaneous bundle and has been drawn on the external side throughout. Commonly it is on the antero-median side.

In the foregoing experiment the high degree of irritability of the bundles indicated that they had not been damaged in the process of isolation. It follows that they could have been sutured separately though their small size would have made it a difficult operation. In such a case as this, separate suture of the nerve bundles would reduce to a

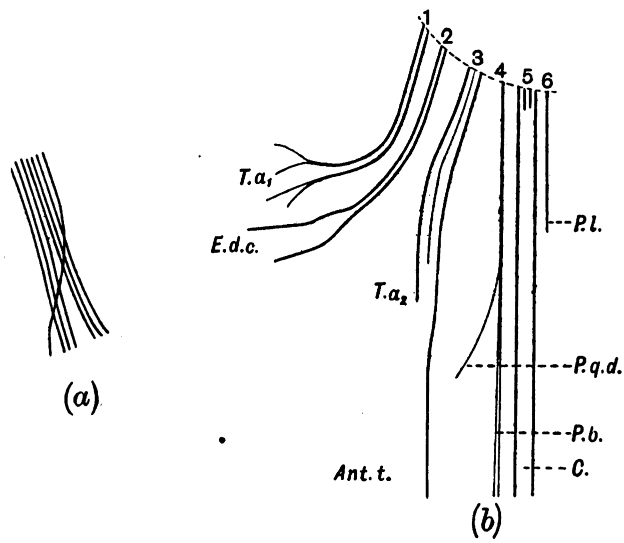

Fig. 1. (*a*) Bundles of peroneal nerve (cat) as seen in preliminary dissection in the experiment given in the text.

(*b*) Diagrammatic sketch of nerve filaments in the peroneal nerve at the point where it passes under a slip of the outer head of the gastrocnemius (cat). 1. For upper part of tibialis anticus. 2. For extensor dig. comm. 3. For lower part of tibialis anticus. 4. For peroneus quinti digiti and per. longus. 3. Cutaneous portion of musculo-cutaneous. 6. For peroneus longus. Lettering as in Fig. 2.

minimum both distortion of the nerve pattern, and interchange of muscle and cutaneous fibres. The result suggested an investigation of the nerve bundles in the proximate part of the nerve in order to see in what length of nerve trunk separate suture was possible. The facts noticed led us to make comparative observations on the tibial nerve of the cat, and on the sciatic of dog, goat and man. We are indebted to Dr Shore for a fresh sciatic of man, and to Prof. Macalister for two specimens from the dissecting room. A further comparison with the nerve bundles in the sciatic of man was made possible by an account published by Compton (12) whilst our investigation was in progress.

We may recall some known facts with regard to the structure of the sciatic nerve in man. It consists of bundles or funiculi which are characterised by having a perineurial sheath; they are joined together by epineurium and so form the nerve trunk. In parts of the nerve trunk the bundles have communicating branches and so form a plexus. The peroneal and tibial divisions of the sciatic, however, run a separate or almost separate course and not infrequently they arise separately from the lumbo-sacral plexus. The nerves given off from a nerve trunk to run to muscles rarely, if ever, have communicating branches with other nerves, they divide on their course and form a plexus in or close to the muscles. The cutaneous nerves given off from a nerve trunk run a separate course for some distance but usually form a plexus with other cutaneous nerves near the periphery.

The existence of a plexus in the sciatic nerve of man was described early in the last century. A figure of it is given in Blandin's edition of Bichat's *Anatomie Générale* published in 1832. Schäfer (9) describes the funiculi of a nerve as constantly branching and uniting with other funiculi so that it is impossible to tease out a single funiculus for any distance.

We shall speak of the plexus whether occurring in a nerve trunk or in a branch proceeding from it, as an *internal nerve plexus*. Our method of treating the nerves of lower animals for dissection was, as a rule, to place them fresh from the body in 30 p.c. alcohol containing 1 p.c. acetic acid; in this the epineurium swells up and the nerve bundles are easily followed. Occasionally the smaller nerves were placed in 1 p.c. osmic acid for a day, washed well, and kept in 30 p.c. alcohol until examined. The nerves of man were placed in 75 p.c. alcohol for a few days, kept in 30–50 p.c. alcohol and the epineurium cut away piece by piece.

In a nerve trunk, even in one of small size, the epineurium is not usually in equal amount between the nerve bundles but is disposed so as to divide them into groups. The epineurium between the bundles in a group varies in amount and sometimes it is so small that the constituent bundles are not seen under the dissecting microscope. A group is often formed by the division of a bundle, the branches remaining in close apposition. Two or more bundles joined more closely than the rest we shall speak of as a *bundle group*. Not uncommonly the bundles of a bundle group form a plexus although there is none in the same region between adjoining bundle groups.

In all our cases the two divisions of the sciatic diverged in the upper part of the popliteal space. As this is the usual point of divergence we may speak of the peroneal and tibial divisions of the sciatic above this point as the sciatic peroneal and sciatic tibial. The rest of the peroneal division we shall speak of as the peroneal nerve, only using external popliteal when it is necessary to emphasize that the upper part of the nerve is referred to.

The peroneal nerve and its branches.

In the experiment given above (p. 321) the peroneal nerve in the lower part of its course consisted, as we have said, of seven bundles supplying different regions; the outer three went to make the anterior tibial nerve, the median four the musculo-cutaneous nerve. But the number of bundles at corresponding points varies in different cats. This depends chiefly on the point at which the single bundles divide and form bundle groups. In the case given in Fig. 1 *b* of the peripheral course of the nerve, four of the primary bundles shown in Fig. 1 had divided, and the cutaneous branch for the foot instead of consisting as in Fig. 1 *a* of two bundles separated by obvious connective tissue, consisted of three bundles very slightly separated from one another. There is, however, no special difficulty in recognising the nerves for the separate muscles and in distinguishing these from the cutaneous branch of the musculo-cutaneous nerve, if the nerve is exposed for 1 to 2 cm. In the lower part of the nerve trunk, the nerve to the per. longus can be told by its running obliquely across the other nerves (cp. Fig. 2).

On tracing the bundles centrally it is found that they join to make three bundles or bundle groups. One consists of the nerve supplying the tibialis anticus muscle, the extensor digitorum communis and of the branch of the anterior tibial nerve running to the foot. Another consists of the cutaneous fibres of the musculo-cutaneous nerve. The third supplies the peronei. The bundles of the first of these groups join to make a single bundle before entering the nerve trunk, so also do those of the third group. The cutaneous bundle group varies considerably in its internal structure; it may join the trunk of the nerve as two or as several bundles; there is a plexus somewhere in the upper part of its course; in the lower part it usually consists of four closely united bundles with very few cross connexions. Three variations are shown in Fig. 2, the bundles being separated from one another.

There are also variations in other details. The point of union of the peripheral nerves into nerve bundles may be at any point where the nerve runs over the gastrocnemius muscle. The union of the bundles to form the nerve trunk may be anywhere in the popliteal space. In joining the trunk, the position of the cutaneous bundle and of the bundle for the peronei varies; usually the cutaneous bundle is in the

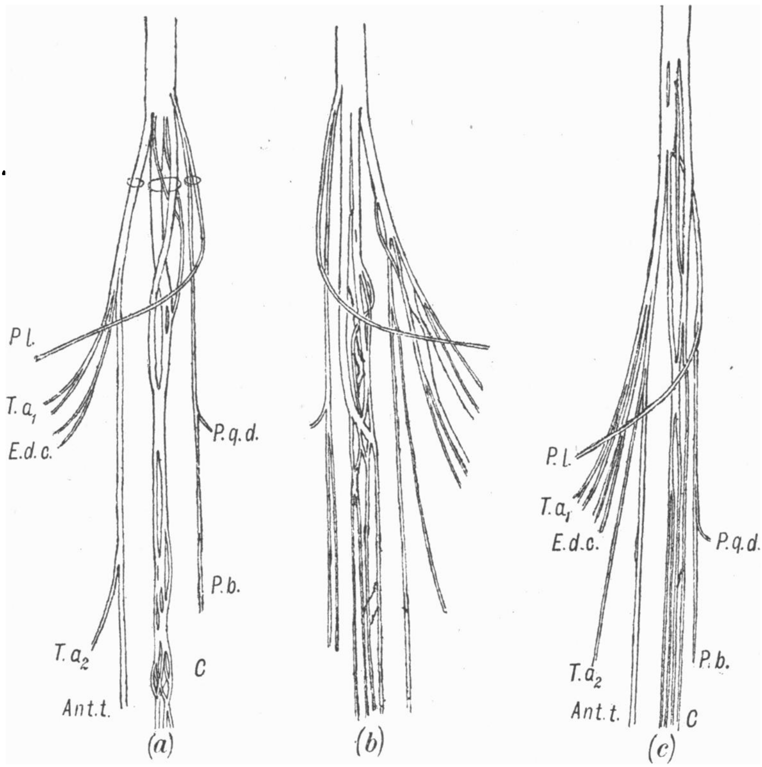

Fig. 2. Three variations in the nerve bundles given off by the peroneal nerve in the cat. In (*a*) rings are placed round the bundle groups into which the nerve divides, in the normal state the bundles are close together. *T.a*$_1$ nerve to upper end of tibialis anticus. *E.d.c.* n. to extensor digitorum communis. *T.a*$_2$ n. to lower part of tibialis anticus. *Ant.t.* anterior tibial n. to foot. *C.* cutaneous branch of musculo-cutaneous n. *P.l.* n. to peroneus longus. *P.q.d.* n. to peroneus quinti digiti. *P.b.* n. to peroneus brevis.

middle of the posterior surface and the bundle for the peronei in the antero-median surface. In one point we have found no variation, viz., that the trunk of the nerve consists of a single bundle. As regards the peripheral course of the nerves, it need hardly be said that the nerves for the peroneus quinti digiti and peroneus brevis run with the cutaneous branch of the musculo-cutaneous nerve. The two are closely connected in this part of their course, forming a bundle group but they have no communicating branches, and can be separated from one another.

A small nerve proceeds from the n. peroneus brevis towards the foot—so far as we have seen to the ankle joint.

General description of figures. All the figures unless otherwise mentioned are drawn from the posterior surface, but since the bundles are separated from one another and spread out in one plane, the figures give to a slight extent only the normal position of the bundles.

In the rabbit and dog the peroneal nerve in its proximal part is formed of a single nerve bundle, and, as in the cat, it divides into three bundles or bundle groups. In the cat, so far as we have seen, the nerve for the peroneus brevis always comes off from the trunk in common with the nerve for the peroneus longus. This is not constant in the dog and is infrequent in the rabbit. In the rabbit it arises as a rule from the musculo-cutaneous bundle, in the dog it may arise by one branch from the musculo-cutaneous nerve and by another from the anterior tibial (cp. Fig. 9 *a*). Whether the nerve fibres for the per. brevis join those of the per. longus in the trunk of the nerve we have not investigated.

In the goat the peroneal nerve consists of a plexus (cp. below), from this arise three bundle groups of the same constitution as in the cat.

Compton describes the peroneal of man as consisting of three bundles in addition to the peroneus cutaneus, which we may omit since it arises from the sciatic peroneal. In the two cases we examined, the "bundles" were bundle groups. We may conclude that from the point of view of internal structure the peroneal nerve in all mammals divides into three bundles or bundle groups.

Since in the cat and goat, and sometimes in the rabbit and dog, we had found that the nerve for the peroneus longus and peroneus brevis came off from a common bundle, we traced the origin of the n. peroneus brevis in one case in man; in this the superficial origin of the nerve was, as usual, from the musculo-cutaneous nerve a considerable distance from the point where the nerve to the peroneus longus left the peroneal; we found that there was no nervous connexion between it and the cutaneous bundles and that it arose from the same bundle group as the peroneus longus (cp. Fig. 3 *a*). Professor Macalister—who has been kind enough to give us the advantage of his knowledge on a number of points—tells us that the nerve for the peroneus brevis sometimes comes off direct from the nerve to the peroneus longus. Thus in man the three divisions of the peroneal nerve have sometimes at any rate the same constitution as that described above in the cat and goat.

Compton describes the bundles as lying side by side in the lower part of the peroneal nerve and as changing their positions in the upper part; the n. peroneus longus being on

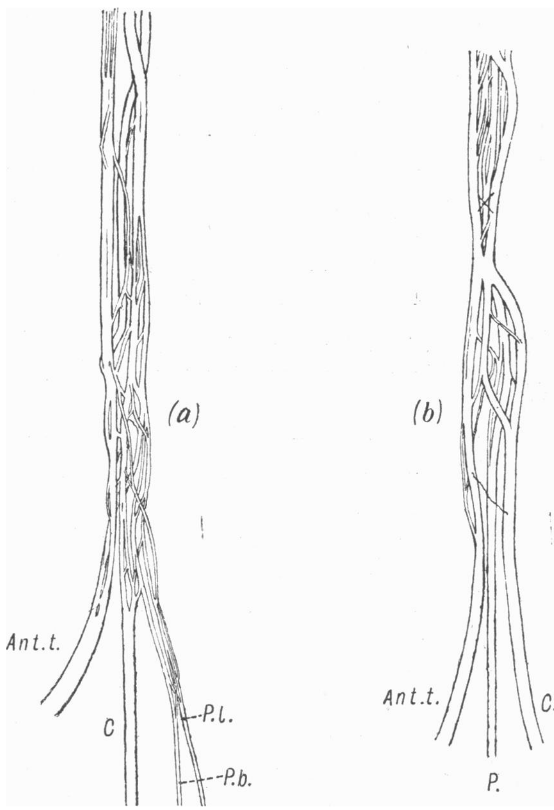

Fig. 3. Bundle groups of peroneal nerve of man and their origin from a plexus in the popliteal region. Two specimens are shown, it will be seen that the details of the plexus differ considerably. The bundles of the bundle groups below the general plexus are not isolated except in the group for the peronei in (*a*). The groups are arranged in the way most convenient for showing the plexus. *Ant.t.* anterior tibial bundle group. *P.* group for peronei. *C.* cutaneous group. *P.l.* nerve for peroneus longus. *P.b.* nerve for per. brevis.

the posterior surface, beneath this the musculo-cutaneous and beneath this again the anterior tibial. In our specimens, in the upper part of the peroneal the antero-tibial group was antero-external, the position of the two other groups was not constant. The formation of the bundle groups occurred about 2·5 cm. from the divergence of external and internal popliteal.

The internal structure of the sciatic peroneal nerve.

In the rabbit, cat and dog the sciatic peroneal in all the cases examined consisted of a single nerve bundle, except that occasionally in the cat the division into three bundles spoken of above occurred in its extreme lower portion.

In the goat the plexus which is present in the upper end of the external popliteal nerve continues for a short distance in the sciatic peroneal. The communicating branches are numerous. Above this region is one in which there are a large number of bundles—more than a dozen—with only a few communicating branches (Fig. 4). The bundles are arranged in three to five bundle groups, and there is some plexus formation between the bundles of each group, but little or none between the groups themselves. In the proximal part of the nerve trunk there is a fairly close plexus (Fig. 4) and the bundle groups which lower down are separate, become more or less connected.

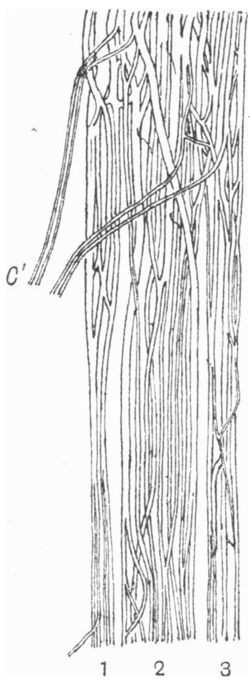

Fig. 4. Sciatic peroneal of goat in the upper part of the intermediate region, and the lower part of the proximal plexus. 1, 2, 3 the three bundle groups. *C′*. cutaneous nerves, lower two traced through the biceps to the skin.

Thus in the sciatic peroneal nerve of the goat there are three regions, one in which there is a close plexus—the lower or distal plexus; this continues on for a short distance in the external popliteal nerve. Above this is a region in which there are bundle groups with few or no connexions between the groups but with some connexions between the bundles forming each group; this may be called the intermediate region, it is not sharply marked off from the region above and below it. Above this is a plexus—the upper or proximal plexus —in which the connexions between the bundles are less close and less numerous than in the lower plexus. Taking the nerve as a whole there is no part longer than a centimetre or so in which there is no plexus.

In the cat, dog and goat the sciatic peroneal gives off two or more nerve filaments which run through the biceps to the skin (cp. p. 335).

Whether any of these supply the muscle and correspond with the peroneal nerve to the femoral head of the biceps in man, we have not determined.

In man the connective tissue between the bundles of the sciatic nerve varies in amount. But it is greater than in the goat and the course and connexions of the bundles cannot be properly followed except by cutting it away—a long and tedious process. As in the goat, three regions are present in the sciatic peroneal of man; relatively, however, the upper plexus region is longer and the intermediate region shorter in the latter. The bundles of two sciatics were dissected in the whole course of the nerve. The following data may be given of one case. From about the lower edge of the pyriform muscle to the divergence of the peroneal and tibial nerves (upper part of popliteal space) the distance was about 34 cm. The dense lower plexus of the external popliteal nerve continued upwards in the sciatic peroneal for about 5 cm.

Above this was a stretch of about 11 cm.—an intermediate region—in which the plexus was relatively slight. In the lower 8–9 cm. of this the bundles formed two large bundle groups, each consisting of smaller ones. With the exception of one small bundle group the groups exchanged few bundles, had few communicating branches, but their constituent bundles formed here and there a plexus.

Just above this intermediate region, the several bundle groups formed a fairly close plexus, and there was plexus formation in most of the rest of the nerve trunk; it was broken by a short stretch in which the arrangement was like that of the intermediate region.

The nerve to the short head of the biceps ran a long course (16 cm.), at first at the side and then on the anterior surface of the trunk and arose from the uppermost part of the plexus (cp. Fig. 10 *B*).

In the other specimen the arrangement was essentially the same, though the intermediate region was a little longer, and the upper plexus formation rather less.

The tibial nerve and its branches.

The posterior tibial nerve of the cat and dog below the muscle nerves for the leg consists of two bundles or bundle groups and, so far as we have seen, these have no communicating branches between them. The mass of the fibres of each bundle group runs on into the external (lateral) plantar nerve, and that of the other bundle group into the internal (medial) plantar nerve. They give off, of course, also articular and cutaneous branches; but we may for brevity call them the internal and external plantar groups. In each group the bundles in their peripheral course divide, have some communicating branches, and here and there unite. The external plantar group is formed of fewer bundles than the internal plantar and it may be a single bundle for a considerable part of its course. The details vary, we give three sketches from different animals in Fig. 5.

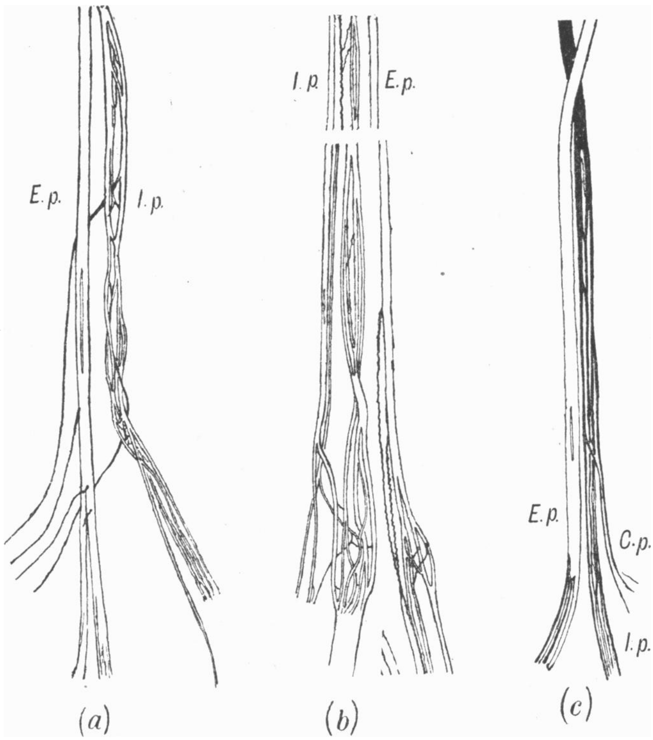

Fig. 5. Posterior tibial nerve. (*a*) and (*b*) Two varieties in the cat. (*c*) A form in the dog. *E.p.* external plantar group. *I.p.* internal plantar group. *C.p.* calcaneo-plantar group. In (*b*), the bundles in the lower end of *I.p.* are not isolated, and about 2½ centimetres are cut out of the upper part.

In the goat also the posterior tibial nerve consists of an external and internal plantar group. In the case most completely examined (Fig. 6), the external group just below the muscle nerves consisted of three bundles and the internal group of five bundles. There were two slender bundles running from one of the bundles of the one group to one bundle of the other, apart from this they ran a separate course. In each group the fibres divided on their way down the leg forming in each about a dozen bundles. The bundles ran a fairly isolated course, but there were a few communicating branches and the secondary bundles here and there reunite.

We have not paid much attention in dissection of any of the animals to the afferent branches but in the cases examined the calcaneo-plantar nerve came off from the internal plantar group. Near the ankle it forms a more or less separate bundle group.

In order to determine the practicability of isolating the nerves in the trunk we made two experiments on the cat and one on a small dog. The connective tissue between the groups is small so that it is not very easy to distinguish groups from bundles, or to isolate them without injury. In each case three bundle groups were isolated, 4–5 cm. above the ankle, two of them gave the characteristic effects of the external and internal plantar nerves; the third in two cases was purely afferent, in the other case it caused slight muscular contraction, which ceased on separating a small filament from it.

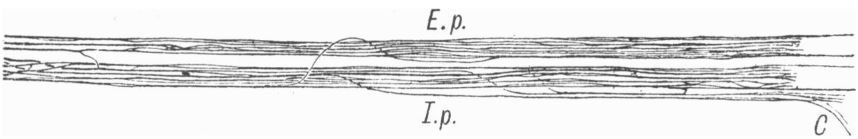

Fig. 6. Posterior tibial nerve of the goat from a little below the origin of the muscle nerves down to the ankle.

The posterior tibial of man in the greater part of its course consists of two bundle groups as in lower animals; each is made up of 6 to 7 bundles which are considerably larger than in the goat. So far as we have seen there are no communicating strands between the bundles, but from the analogy of the arrangement in the goat, we may expect that a few sometimes are present. In each group there is a slight plexus formation between most of the bundles. The connective tissue between the groups is not great, but after slitting up the epineurium it was, post mortem, fairly obvious. In the upper part of the posterior tibial the muscle nerves given off by it run a separate course in the trunk, these and the plantar bundle groups join into a common plexus in the internal popliteal.

In the cat and dog the internal popliteal nerve is usually formed of a single nerve bundle except where peripheral nerves run in the sheath before diverging from it. The plantar bundle groups, the muscle nerves given off by the posterior tibial, the nerves for the popliteus and plantaris muscles, enter the single bundle close together (Fig. 7).

In the goat, the internal popliteal consists of many bundles forming a close plexus. Into this plexus run the plantar bundle groups, and the nerves for the muscles just mentioned. The muscle nerves arise chiefly

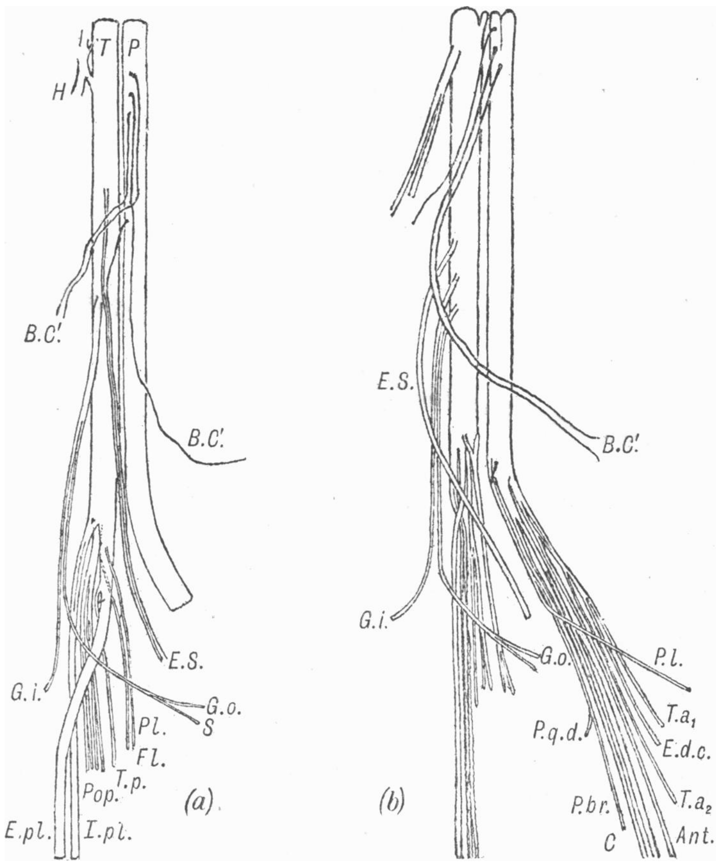

Fig. 7. Entrance of peripheral nerves into the single bundle of the sciatic tibial nerve of the cat and dog. The gastrocnemius, soleus, and cutaneous nerves are separated from the nerve trunk and drawn to one side.

(*a*) Cat. (*b*) Small dog. *E.S.* external saphenous nerve (sural). *G.i.* nerve for inner head of gastrocnemius. *G.o.* for outer head. *S.* for soleus. *Pl.* for plantaris. *Fl.* for dig. com. *T.p.* for tibialis posticus. *Pop.* for popliteus. *E.pl.* external plantar group. *I.pl.* internal plantar group. *B.C'.* nerves traced through biceps to the skin. Other lettering as in Fig. 2.

from the anterior surface of the plexus; the nerve for the plantaris coming off from the plexus higher than the rest (cp. Fig. 9 *b*).

In man the general arrangement is as in the goat; since the muscle nerves except those for the gastrocnemius and the main part of the soleus arise fairly close together from a common plexus we need not consider them in detail.

The internal structure of the sciatic tibial and the origin of its muscle nerves.

The sciatic tibial of the cat and dog, as the internal popliteal, usually consists of a single bundle except for the peripheral nerves running in it. The nerve for the outer (lateral) head of the gastrocnemius and the whole supply of the soleus, come off from a common bundle; this bundle—tracing it upwards—sometimes joins that of the inner (medial) head of the gastrocnemius (cp. Fig. 7 *a*) and the conjoined nerves run a variable distance upwards—it may be 3 cm. or more—as a single bundle in the tibial trunk; sometimes the two nerves enter the trunk separately (cp. Fig. 7 *b*). The common bundle when of any length, or the nerves to the two heads of the gastrocnemius, since they are on the posterior surface of the trunk can be isolated fairly easily.

In the goat, the arrangement of the nerves for the gastrocnemius and soleus (Fig. 9 *b*) is like that in the cat and dog, but the common bundle group has a longer separate course in the trunk of the nerve, and the nerves join the plexus which continues upwards from the posterior tibial nerve.

In man, in our three cases, the nerve for the inner head of the gastrocnemius and that for the outer head and soleus could be followed for 9–10 cm. on the posterior surface of the nerve trunk (internal popliteal and sciatic tibial). In part of its course it may be covered by the tibial saphena (medial sural cutaneous). In two cases the nerves were joined into a common bundle in the upper part of their course; in the other they ran separately, the nerve for the outer head running rather farther up than that for the inner head. Although the nerves enter the plexus chiefly in the upper part of their course, they give small filaments to it at several points below (cp. Fig. 10 *G*).

The sciatic tibial of the cat and dog usually, as we have said, consists of a single bundle. We found one marked exception in a cat weighing 3·5 kilos. The nerve consisted of two or of three main strands forming a plexus (cp. Fig. 8). It will be noticed in the figure that there is relatively little bundle or plexus formation below the origin of the nerves to the gastrocnemius and soleus, but that there is a fairly close plexus in all the regions above this. The hamstring nerves arose from the plexus in the most proximal part of the trunk. We had expected to find a similar plexus formation in large dogs, but in the one we examined the nerve consisted of a single bundle except for about a centimetre where it consisted of two bundles.

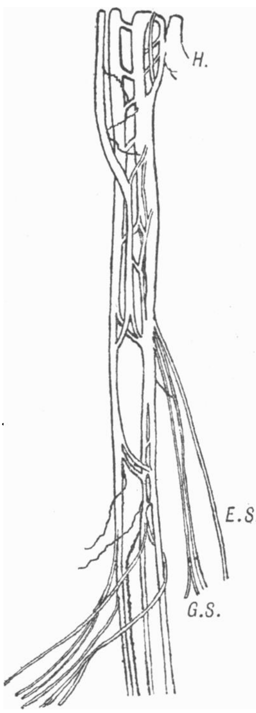

Fig. 8. Left sciatic tibial of large cat, showing plexus formation. Anterior surface. *G.S.* nerves to gastrocnemius and soleus. *E.S.* external saphena. *H.* hamstring nerves.

In the goat the sciatic tibial has no definite intermediate region corresponding with that of the sciatic peroneal. But the plexus is less for a short distance below the origin of the nerves to the hamstring muscles than either above or below it. In this region the plexus formation does not usually affect all the bundles in any one centimetre of its length, but breaks out first in one group and then in another. It is in fact only at the origin of the leg muscles and in a portion of the upper part of the nerve trunk that all the bundles have communicating fibres close together.

In both our specimens of the sciatic tibial of man the tibial saphena (medial sural cutaneous) was small. The details are no doubt somewhat different when the nerve is large. The sciatic tibial may be divided into three regions. Proximally there is a short region consisting of a close plexus of small bundles, and of a few larger bundles unconnected or but slightly connected with the plexus. It was about 3 cm. in our specimens but it probably continues farther upwards under the pyriform muscle. From this issue large nerve bundles, some of which a little lower down, after additional slight connexions, become the nerves to the hamstring muscles and adductor magnus. The upper plexus is followed by a long region (13–16 cm.) consisting of nerve bundles having the characters described above (p. 328) of an intermediate region. In the specimen which had much connective tissue, there were two large bundle groups roughly antero-lateral and postero-medial, these had only about half-a-dozen bundles running each way between them; each consisted of smaller groups with more frequent connexions.

In the lower part of the intermediate region the superficial medial bundles curve over

the lateral, and in one case they curved over a part of the peroneal trunk making the distinction of peroneal and tibial difficult to make out on the surface.

The end of the intermediate region is marked by the bundles, with the exception of one or two of the medial group (cp. Fig. 10 b_2), forming a fairly close plexus which continues in passing downwards and becomes much closer in the lowest part of the sciatic tibial and in the internal popliteal. In the upper part of this plexus there are one or two bundles having a relatively long separate course (cp. Fig. 10 b_1). The bundles of the sciatic tibial are on the whole considerably larger than those of the sciatic peroneal.

We may note that neither in lower animals nor in man were there communicating branches between the plexuses of the peroneal and tibial.

The account given above of the plexuses of the sciatic differs in several points from that of Compton. He describes both peroneal and tibial divisions of the sciatic as having little or no plexus in the upper third, a more or less close plexus in the middle third and none in the lower third. The nerve was taken from the lower edge of the glutæus maximus to the level of the knee joint. The most important difference is that we find a fairly close plexus in the upper part of both peroneal and tibial divisions. It is to be noted however with regard to the tibial division that Compton did not complete an examination of its upper part. He mentions that the examination so far as it went suggested the presence of a plexus smaller than the lower and formed by a branching of the nerves supplying the hamstring muscles. An important difference also is that we do not find the internal structure of the two divisions to be symmetrical. But it is possible that when the tibial saphena is larger than the peroneal saphena, the symmetry may be greater than in our cases.

The cutaneous branches of the sciatic.

The origin of the cutaneous branches of the sciatic varies considerably. In the cat, dog, and goat, there is, so far as we have seen, no peroneal lateral cutaneous branch corresponding in course to that of man, but the sciatic peroneal sends a cutaneous branch through the lower part of the biceps (Fig. 7 *B.C'.*) which apparently represents it. There may, however, be more than one cutaneous branch as in Fig. 9 (*a*).

The external saphenous nerve (sural), whilst arising mainly from the sciatic tibial, usually has near its origin a small filament from the sciatic peroneal (Fig. 7). The origin of the nerve in the cat and dog is as a rule but a short distance above the origin of the nerves to the gastrocnemius (Fig. 7); in one case—a large dog—it arose from the same level, but received a slender nerve from the upper part of the tibial (Fig. 9 (*a*) *E.S'.*).

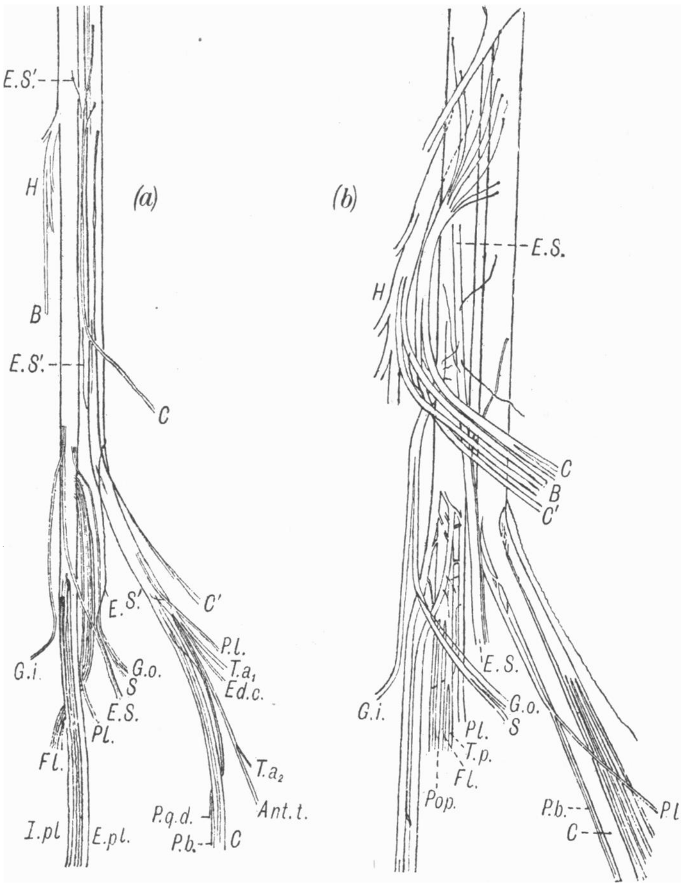

Fig. 9. (*a*) Origin of nerves from the sciatic of a large dog, each division being formed of a single bundle. (*b*) Origin of nerves from plexuses in a goat. At the upper part of the specimen the tibial and peroneal formed a common plexus arising immediately from the sciatic plexus. *H.* hamstring nerves. *B.* nerve to biceps. *C'.* nerves traced through biceps to the skin; in (*b*) *B.* and *C'.* diverged just after the point drawn. *E.S.* external saphena. *E.S'.* filament to external saphena from the upper part of the tibial. Other lettering as in Fig. 7.

In the goat, the external saphena runs a long separate course on the posterior surface of the trunk of the nerve, joins the upper plexus about midway between the origin of the gastrocnemius nerves and that of the hamstring muscles and has one or two branches from the peroneal on its way (Fig. 9 (*b*) *E.S.*).

In both the human sciatics we dissected, the tibial saphena was much smaller than the peroneal saphena; in one it was about one-third the size of the latter, in the other it was less than a third. In the former the peroneal contingent (anastomotic branch) crossed to the tibial immediately below the divergence of the two divisions of the sciatic. The tibial saphena had a relatively short course and joined the lower plexus in the same region as the upper filaments of the gastrocnemius nerves (Fig. 10). The peroneal saphena ran a long separate course—about 17 cm.—in the sciatic peroneal, and joined the lower part of the upper plexus. The lateral cutaneous ran a still longer separate course—about 24 cm. *i.e.* about 9½ inches—and joined the upper plexus a little below the nerve to the femoral head of the biceps (Fig. 10). In the other specimen the lateral cutaneous and peroneal saphena formed a single bundle which began to form a plexus a little higher up than the tibial saphena in the first case, and it received a small filament from the peroneal division where it joined the plexus.

It will be seen from what has been said in this and in preceding sections that both upper and lower plexuses of the sciatic trunks give off both muscle and cutaneous nerves. The broad rule is that both muscle and cutaneous nerves arise from a plexus. If they arise, as they sometimes do, from the same part of the trunk the plexus in that part is common to the two classes of nerves; as the origins diverge the plexuses diverge also, but remain more or less connected.

Compton came to the conclusion that "the plexus may be supposed to consist almost entirely of motor nerves." By motor nerves he presumably means muscle nerves, since the nerves to muscle contain sensory as well as motor fibres. His remarks suggest that muscle nerves arise from a plexus and that cutaneous nerves do not. The basis for his conclusion is that he found in ten out of twelve cases that the peroneal cutaneous and tibial communicating nerves ran a completely independent course, and that the posterior tibial appeared to be only slightly connected with the plexus. It is true that the former nerves pass more or less completely by the lower plexus, but they arise from the upper plexus of the nerve. The posterior tibial has intimate connexion with the lower plexus.

Consideration of results.

We have seen that whenever the sciatic peroneal or sciatic tibial is not a single bundle, a plexus is formed in it. If the single bundle of the peroneal or tibial in the rabbit or cat is teased out, it is found that there are numerous obliquely running and crossing fibres, and these are in greater number where nerves are given off. In all cases then an internal

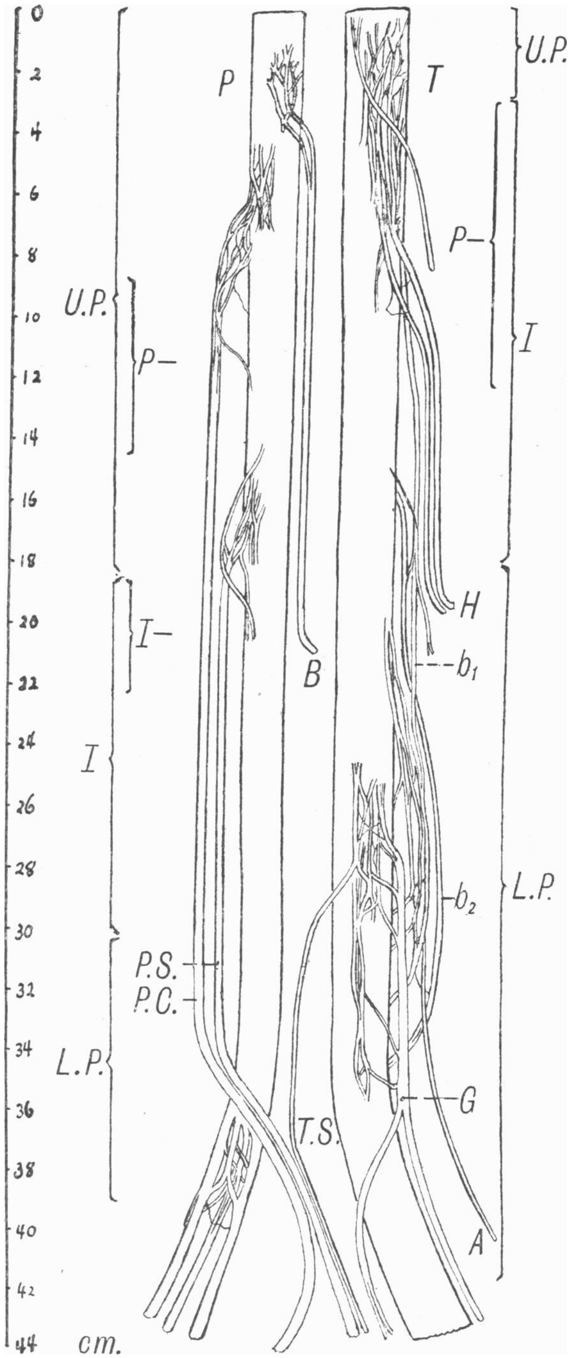

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Fig. 10.

nerve plexus occurs; in small nerve trunks it is formed of nerve fibres and in large nerve trunks it is formed of nerve bundles. Further in cross section of the sciatic of the cat and dog there are usually some thicker strands of endoneurium dividing each trunk into areas, these areas may be regarded as the beginning formation of bundles.

A comparison of the nerves in different animals shows that the formation of bundles depends on several factors. The size of the nerve is no doubt an important factor inasmuch as in general nerves beyond a certain size consist of bundles. The advantage of the formation of bundles is that the arteries and veins can be kept outside the perineurium and thus pressure on the nerve fibres is avoided or lessened when there is increased arterial and venous pressure, and the pressure in all parts of the capillary system is kept more constant. But size is not the only factor for a nerve proceeding from a trunk may consist of bundles, though the trunk itself is a single bundle. The family to which an animal belongs appears also to be of influence, for the number of bundles is relatively greater in the goat than in man; and relatively much less in cat and dog than in the goat.

There are various grades of plexus formation. In the lower part of the sciatic peroneal and sciatic tibial, all the bundles have communicating branches within a distance of about a centimetre. In the uppermost parts of these nerves the same is in general the case, though in the tibial of man there are a few bundles but slightly connected with the plexus a little below the lower edge of the pyriform muscle. A certain decrease

Fig. 10. Origin of nerves from the sciatic plexuses in man. The plexus is only drawn at the point of origin of the nerves and irrespective of whether it is on the anterior or posterior surface. The brackets show the extent of *U.P.* upper plexus; *I.* intermediate region; *L.P.* lower plexus, in the respective peroneal and tibial divisions. In the peroneal, *P–* marks a stretch of the upper plexus in which the plexus was less than above and below it. *I–* marks a stretch in which the characters of the intermediate region were less developed and the plexus greater than below. In the tibial, *P–* marks a portion of the intermediate region in which though rather more than a third of the nerve had scarcely any plexus the rest had a moderately developed plexus. The upper half of the lower plexus of the tibial consisted of a varying number of bundle groups running at different points an isolated course for 2 to 3 centimetres. In the external popliteal the beginning of the plexus formed by the three bundle groups is shown. The nerves, the bundles b_1, b_2, and some bundles connected with b_1 are pulled away from the trunk. *H.* hamstring nerves. *B.* nerve for femoral head of biceps. *T.S.* tibial saphena. *P.S.* peroneal saphena. *P.C.* lateral cutaneous. *G.* nerve for gastrocnemius. *A.* probably articular branch. b_1 a bundle arising from the upper plexus and running a long separate course, most of the fibres of *A.* came from it. b_2 a long separate bundle arising from the intermediate region.

of plexus is marked by the bundles being arranged in groups, which have only slight connexion with one another, although the bundles of each group have still fairly numerous connexions. A still further decrease may occur by the constituent bundles of a group being also only slightly connected, as in a considerable portion of the posterior tibial of man. We have called a region in which there are bundle groups with only slight connexion with one another an intermediate region, but the limits of such a region cannot in general be fixed with any accuracy since near a close plexus more numerous connexions are found between some bundle groups than between others.

We have seen that the intermediate region does not occupy the same level in the two divisions of the sciatic, and that there is a long intermediate region in the tibial division of man, but no definite one in the tibial division of the goat. We have seen also that about the origin of each peripheral nerve, mainly a little above it, there is an increase in plexus formation. A consideration of the position of the nerves arising from the peroneal and tibial divisions in the goat and in man shows that an intermediate region occurs when there is a certain distance between the origin of the nerves. The greater the distance the longer the intermediate region, subject to two other factors. The greater the bulk of nerves arising from a given short stretch of the trunk, the farther above this the close plexus extends, thus the lower plexus stretches farther up the sciatic tibial than up the sciatic peroneal. The second factor is that in the division of bundles to make a peripheral nerve a preliminary sorting out of bundles commonly occurs for nerves issuing lower down, so that the plexus does not at once diminish below the origin of a peripheral nerve.

The internal plexus obviously serves to collect together the afferent and efferent fibres of different nerve roots for the areas supplied by the peripheral nerves. The lumbo-sacral plexus does the same for the large areas supplied by the nerve trunks. The internal plexuses, in fact, continue the process begun by the lumbo-sacral plexus.

In the two cases in which we had the whole of the human sciatic trunk, the tibial saphena was considerably smaller than the peroneal saphena. It is well known that the tibial and peroneal contingents of the external saphena are variable in man, but the tibial is usually larger than the peroneal contingent, and in all the lower animals we examined it was much larger. The point of interest is that in the two cases of man just mentioned the tibial saphena arose from the lower plexus in the region in which also the greater part of the gastrocnemius nerves arose instead of arising from the upper plexus. In one other case in which we had only the lower part of the sciatic, the tibial saphena was larger, part of it was connected with the lower plexus, but a part ran an isolated course upwards. Probably, then, there is a constant contingent arising from the upper part of the lower plexus, and a variable contingent arising from the lower part of the upper plexus.

It is noteworthy that the long isolated course of the internal saphena outside the trunk of the crural nerve is analogous with the long isolated course of the peroneal lateral cutaneous and peroneal saphena in the trunk of the sciatic. It appears indeed to be a general rule that cutaneous nerves run a longer isolated course than muscle nerves.

The complexity of the lower plexuses in the sciatic of the larger mammals makes it, we think, certain that, so far as dissection goes, no bundle above the plexus can be said to correspond even approximately with any bundle below it. It is true, as Compton remarks, that the superficial bundles of the peroneal and tibial nerves as seen without dissection run direct over the lower plexus into the upper part of the nerve. But when the connective-tissue is cut away and the full extent of the plexus is displayed, it is obvious that all the nerve fibres in any one superficial bundle in the lower region might have passed completely into other bundles in the upper region. This may be judged from Fig. 3, bearing in mind that it represents but a small part of the plexus. Thus, above the lower plexus, dissection does not warrant a division of the peroneal trunk into an anterior tibial and a musculo-cutaneous portion, or a posterior tibial part to be distinguished in the tibial trunk, and still less does it warrant any particular bundle to be labelled the bundle for the gastrocnemius, plantaris and so forth.

Compton found no communicating bundles visible on the surface. We find some, though relatively few. Such bundles are obvious in the internal popliteal nerve. The greater number of communicating bundles in the internal part of a nerve is the natural result of some of the bundles being entirely surrounded by the superficial bundles.

Whilst the connexions of the bundles centrally of the plexus with those peripherally of it cannot we hold be determined by simple inspection, it is not unlikely that some fibres keep their lateral, median, or other position in passing through the plexus since a complete crossing of fibres, apart from twisting of the whole trunk, seems meaningless. The degree of crossing could be settled by stimulating the bundles separately in a large mammal.

The question was rather beside our immediate object and we have only made one experiment on the common peroneal of a cat, an experiment which is not very satisfactory since the trunk consists of a single bundle only. In an anæsthetised animal the perineurial sheath was cut open about 4 cm. below the great sciatic foramen. The main divisions of the endoneurium were fairly distinct, these were followed and the nerve divided into four strands. The postero-external strand caused strong contraction in the tibialis anticus muscle, and possibly of a few fibres in the extensor dig. comm. The antero-external strand caused less strong contraction in the tibialis anticus and strong contraction of the extensor dig. comm. The postero-medial strand caused contraction in the extensor dig. comm., in the peroneus longus and the peroneus brevis. The antero-medial strand caused contraction in the extensor dig. comm., the peroneus longus, peroneus brevis, and peroneus quinti digiti. No great stress can be laid on this experiment since the divisions of the nerve may have been artificial, but, so far as it goes, it shows that the tibialis anticus received the whole of its efferent fibres from the external part of the nerve, and the peronei from the medial part, that there was large overlapping in three of the four strands into which the nerve had divided, and that none of the four was purely afferent.

Two other conclusions may be drawn from the facts described as to the internal structure of nerve trunks. (*a*) The observations hitherto recorded upon the time of recovery on cross suture of nerves, and on the degree of adaptation of the nerve centres, have been made on nerve trunks with the exception of some on the cranial nerves. Whilst these present problems of their own, data of a much clearer character would be obtained by cross suture of peripheral nerves. (*b*) Since in the dog both the sciatic peroneal and sciatic tibial consist of a single bundle, and in man of many bundles separated by a considerable amount of epineurium, the results on nerve suture in the one are only a partial guide to what happens on nerve suture in the other. The probable result of the larger amount of connective tissue in man is to cause a larger number of fibres to go astray.

The primary object of our observations was to determine in what cases separate suture of nerve bundles in a nerve trunk would lessen the disturbance of nerve pattern. It is we think certain in view of the large number of bundles present in most nerve trunks in man and larger animals, and of their flexibility in life, that accurate apposition of the bundles can very rarely be attained. A slight shifting of the normal position will bring a considerable fraction of each bundle of the central end opposite either epineurium or a non-corresponding bundle. Thus there will be loss of power, and distortion of nerve pattern.

The conditions are different above and below a nerve plexus. It does not appear likely that there would be appreciable advantage in suturing separately portions of a nerve trunk above or in a nerve plexus. But separate suture of peripheral nerves in a nerve trunk below their nerve plexus would prevent distortion of nerve pattern and prevent efferent and afferent bundles being brought into apposition.

But whilst the method has theoretically only a limited application, and in practice is still more limited by the difficulty of isolating the bundles and by the time required for isolation and suture, there are nevertheless a not inconsiderable number of cases in which we think advantage is to be derived from it. The cases are of three classes: (1) those in which a peripheral nerve lies in the outer loose epineurial sheath, (2) those in which it lies in the dense inner epineurial sheath, and (3) those in which the nerve trunk consists of bundle groups for separate, or approximately separate, areas.

In the first class are more or less considerable portions of the peroneal and tibial cutaneous nerves, the hamstring nerves, the nerve to the short head of the biceps, the gastrocnemius and upper soleus nerves. Of these the cutaneous nerves are the simplest. The hamstring nerves are surrounded by much connective tissue. The nerve to the short head of the biceps soon dips to the anterior surface of the peroneal. The gastrocnemius nerves have but a short course before they enter the dense epineurial sheath.

In the second class are the upper portions of the peroneal and tibial cutaneous nerves and of the nerves to the gastrocnemius; also (for a short stretch of the peroneal where it runs over the gastrocnemius) the peripheral nerves into which the peroneal divides. These cases could hardly be attempted without a previous study of the course of the bundles in the nerve trunks. It may be noted that in parts of the sciatic the bundles do not take a straight course, so that on simple suture after excision of a piece, the cutaneous bundles are not in contact, or only in imperfect contact.

Separate suture in the third class of cases lessens distortion of nerve pattern, but does not prevent it. Recognition of the three bundle groups into which the peroneal nerve divides does not present much difficulty, but they occur in a short stretch only of the trunk. The internal and external plantar groups have a long course in the posterior tibial nerve with little or no connexion with one another, but on the other hand their separation so far as we have seen is not a simple matter. The muscular and cutaneous branches of the musculo-cutaneous nerve can be separated in nerves removed from the body; how far it is practicable in life we are unable to say.

All the cases mentioned above refer to the sciatic and its branches. There are no doubt similar instances in the nerves to the fore-limb. We have only examined the radial (musculo-spiral). In this the muscular branch (posterior interosseous) and the cutaneous branch (radial) run for some distance an entirely separate course; since the latter is an afferent nerve it would almost certainly be an advantage to split the trunk and suture the two parts separately.

Whilst separate suture in certain cases would we think lead to better recovery, it increases the time taken up by the operation, involves more cutting of blood vessels than simple suture and it may cause increased connective growth. These are unimportant when nerves running in the outer epineurial sheath are dealt with, but it cannot yet be said that they are unimportant when the inner dense epineurial sheath has to be cut open. This interferes more or less with the blood supply to the isolated nerve bundles, and a deficiency of blood supply, though it does not prevent regeneration, probably delays it.

The chief hindrance to nerve regeneration is connective tissue growth; it is not unlikely that this would be lessened by cutting away the surface epineurium at the point of suture, some experiments on this point are in progress by one of us, but for satisfactory results larger animals than those that can be experimented on in the Cambridge laboratory are probably required.

General Conclusions.

In all cases the limb nerves before giving off peripheral nerves, have an internal nerve plexus. If the nerve trunk is a single bundle, the plexus is one of nerve fibres; if the trunk consists of nerve bundles, the plexus is one of nerve bundles.

The formation of bundles in a nerve depends partly on the size of the nerve and partly on the family to which the animal belongs.

The closeness of the plexus varies in different parts of the nerve trunk; it increases a short distance above each region from which a peripheral nerve arises. Each peripheral nerve whether it supplies muscle or skin arises from a greater or less extent of the plexus.

Just as the lumbo-sacral plexus serves to collect together the afferent and efferent fibres of different nerve roots into trunks for more or less separate large areas, so the internal plexuses in the nerve trunks serve to collect similar fibres into bundle groups or bundles for smaller areas.

In the region between the origin of two successive peripheral nerves not arising close together, the bundles are arranged in bundle groups which have little or no connexion with one another, though the bundles forming a group are more or less inter-connected. Such a region may be called an intermediate region, but in general it blends gradually into the regions of close plexus.

The greater the bulk of the peripheral nerves arising from a given short stretch of the trunk, the farther above this the close plexus extends.

The close plexus extends a short distance below the origin of each peripheral nerve and serves for partial re-arrangement of the branches leaving the trunk lower down.

In both peroneal and tibial divisions of the sciatic, there are two plexuses giving off muscle nerves, viz. (*a*) a short plexus in the most proximal region from which nerves arise for certain muscles of the thigh, and (*b*) a longer lower plexus extending into the popliteal nerves, from which arise the nerves for the leg.

The origins of the cutaneous nerves given off by the sciatic trunk vary. In man the peroneal cutaneous nerves arise partly from the upper plexus in common with the muscle nerves but in large part somewhat below this, thus extending the range of the upper plexus. The tibial saphena arises in some cases from the upper part of the lower plexus in approximately the same region as the upper filaments of the gastrocnemius nerves. Probably there is in most cases an additional origin corresponding to that of the peroneal saphena.

Some peripheral nerves, especially cutaneous nerves, run in the nerve trunk for a more or less considerable distance and can be sutured separately, thus lessening crossing of efferent and afferent nerves and other distortion of nerve pattern.

The peripheral trunks in part of their course consist of bundle groups running to more or less separate areas. It is probable that it would be an advantage to suture these separately. But in this case, and in some cases of peripheral nerves, the inner dense epineurial sheath must be cut open, and how far this delays recovery has not been determined.

Twisting a nerve trunk in suturing it will cause a much greater disturbance of nerve pattern if it is done below a nerve plexus than if it is done above it.

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