THE NERVOUS SUPPLY OF THE UPPER EXTREMITY IN ITS MORPHOLOGICAL & PATHOLOGICAL RELATIONS

THESIS

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On the Nervous Supply of the Upper Extremity in its Morphological and Pathological Relations.

Part I.

The question of the primitive derivation of the Upper Extremity in Man, is one upon which comparative Anatomists are not agreed.
Gegenbaur believes it to have been derived from the Gill arches and their Branchial rays, whilst other authorities, amongst whom I may mention Mivart, F. M. Balfour and J. H. Thacker, the latter of whom has paid great attention to this subject, consider that the Upper Extremity is a derivative from a primitively continuous lateral fin, supported by Cartilaginous rays and comparable to the primitively continuous Dorsal median fin.
To enter into the arguments for and against these hypotheses would be entirely beside the subject which I have selected for this Thesis, but I shall endeavour to trace shortly, the various stages of the upper limb from the condition found in the Elasmobranchii, as the derivation from the primitively continuous fin appears to me to be the more probable.
In the development of the Elasmobranchii, two pairs of limbs appear as "differentiations of a continuous but not very conspicuous Epiblastic thickening, which is probably the rudiment of a continuous lateral fin" (Balfour's Comparative Embryology. Vol: II. p: 49.)

Of these two pairs of fins, the anterior develops before the posterior in point of time, and in front of the Umbilicus, whilst the latter appear some distance behind it and approach each other and nearly meet in the median ventral line a little behind the Anus. In the Selachii, also, the anterior paired fins appear before the posterior, but there does not seem to be the same rudimentary indication of a continuous lateral fin. The main part of the cartilaginous framework in the fin of the Elasmobranchii is made up of pieces arranged similarly to the bones in the Mammalian fore-limb, the remainder being composed of irregular pieces of cartilage. The fins in Protopterus are in the form of long filaments, made up of similarly arranged Mesomeres forming an Axis with Pre- but no Post-axial rays, whilst in Lepidosiren there are only Post-axial. We have here got a condition so like the condition found in higher animals that I shall not trace it further, I will only add that it is to be noted that the longitudinal basal bar, or Basipterygium, is at first in a lateral horizontal position and that afterwards it becomes gradually rotated outwards, its anterior end remaining attached to the pectoral girdle.

Before entering on the more special consideration of the Human Upper Extremity it will be convenient to note the arrangement of the Spinal nerves in the forms I have mentioned. In Amphioxus, the nerves arise by a single root from the cord throughout its length, in series with the Intermuscular Septa, which correspond

to this; these nerves divide into Dorsal Primary branches supplying the Median Dorsal region, and Ventral Primary branches supplying the Ventral aspect.
In the Elasmobranchii, we find the nerves arising by two roots, the Superior being purely sensory and marked by the presence of a ganglion, the Inferior purely motor and having no ganglion. These two roots join, except in Petromyzon, below the Posterior root ganglion, their ultimate distribution being, in the main, that already described, in this case there is in addition a branch given off from the Posterior root ganglion.
We now come to the more special study of the upper extremity as found in man. It arises as an outgrowth from the lateral part of the trunk in the 3rd and 4th week after the fertilisation of the Ovum. It does not present any original protovertebral segmentation, but is in some respects to be regarded as a lateral extension of Vertebral somites. (Quain's Anatomy. Vol: II. p. 802.)
It buds out from a lateral ridge near the line of separation of the Mesoblast into its parietal and visceral laminæ, and is at first composed of a mass of Mesoblast covered with a layer of Epiblast which ultimately becomes differentiated into the arm, fore-arm and hand, the bones being formed from cartilaginous plates arising in the centre of the Mesoblast. It seems doubtful whether the muscles proceed directly from the muscle plates or whether they arise locally; probably the Intrinsic muscles arise locally and the Extrinsic, that is trunk-muscles attached to the arm, like the Pectoralis

Major, arise from the muscle plates.
The nerves are the ordinary Spinal nerves, but in this situation, as the limb grows out it carries the nerves out with it and thus prolongs them. The original position of the limb shows it to consist of a Dorsal & a Ventral aspect, which come to be the Extensor & Flexor surfaces respectively, whilst the Radial border is directed forwards and pre-axially, the Ulnar border backwards and post-axially. According to some authorities, an outward rotation of the Humerus takes place as in Quadrupeds, in order, in their case, to allow of the fore-foot being placed to the ground to support the body, a mode of progression usually adopted by infants instinctively, a fact which would lead one to conclude that this rotation of the Humerus does take place, though Quain (Anat. Vol: II p: 805) denies it.
Nerves. The nerves of the upper extremity, with the exception of the Descending Cervical, are all derived from the Brachial Plexus, and it is to this Plexus I shall first turn attention.
We have seen that a typical Spinal nerve in Vertebrates is formed by the junction of two nerve roots, and it then divides into Anterior (Ventral) and Posterior (Dorsal) Primary branches, the latter supplying the Skin and muscles of the back, whilst the former pass round the body in connection with the ribs, and as they do so, they give off lateral branches which divide into Smaller Anterior & Posterior branches for the Skin of the Side. This arrangement holds throughout the whole series

of Spinal nerves in a more or less complicated form, in the Amphioxus and in the Ophidia, where there are no skeletal appendages to alter the arrangement. In Man, too, it holds good in the greater part of the Dorsal region, but in its upper part and in the Cervical region, it is greatly modified. I will not enter into the arrangement of the upper cervical nerves, how they are believed to have been drawn up to supply the head by the enlargement taking place in the Superior (anterior) end of the central nervous system, as this would be beside the issue, as it is so fully entered into by Dr. Ross in his paper on the "Segmentation of the Sensory Nerves. (Brain. Jan: 1888.)

The Brachial Plexus is formed in Man by union of the 5th, 6th, 7th, 8th Cervical and 1st Dorsal nerves with branches from the 4th Cervical and occasionally 2nd Dorsal, i:e: of their anterior primary divisions, (Rami Ventrales) the posterior primary divisions being distributed in their usual manner. The number of nerves entering into the formation of the Plexus varies in different animals, but the 6th (in part), 7th, 8th Cervical and 1st Dorsal are constant. Do the whole of the anterior primary divisions enter into the formation of the Brachial Plexus?

Professor Goodsir thought not, but that the nerves supplying the limb were radiating (Actinal) branches of these. (Anat: Memoirs. Vol: II p: 201. 1868.) He thought that the Intercostal nerves are not serially homologous with the roots of the Brachial Plexus, but that the Thoracic Nerves which are, are the Intercosto-humeral and the Intercosto-cutaneous, i:e: the lateral branches mentioned

above. This, I think, has now been disproved, for, in the first place, if the Plexus only contains representatives of the lateral branches, there is no need distribution to account for the remainder of the anterior primary divisions, which, were such an arrangement the case, one would expect to find supplying the Skin & front of the neck, which we do not. Dr Paterson from a series of dissections in different animals, has concluded that the whole of the anterior (ventral) primary divisions of these nerves, enter into the formation of the Plexus, and, he has been able to formulate these principles, (Journal of Anat: & Physiol: July 1887); —

1st. That the inferior (ventral) primary divisions of the nerves entering this Plexus divide into Dorsal and Ventral trunks.

2nd. That Dorsal divisions of the nerves always combine with Dorsal, and Ventral with Ventral to form nerves of distribution. (To this principle Dr Paterson has since found two exceptions, but both are situated in the Sacral Plexus, viz:- Small Sciatic and Short-Saphenous nerves.)

3rd. That the same Dorsal branches always combine with Dorsal, and the same with the Ventral in all animals.

In the same paper he goes on to Show that the nerves of distribution formed by the union of Ventral branches are distributed to Supply the Skin and muscles of the Ventral (flexor) surface of the arm already mentioned, and the Dorsal nerves supply the Dorsal

(Sclerosor) surface. The following table copied from Dr Paterson's paper will explain more clearly; —

Origin.	Nerves	Distribution.
Ventral Divisions.	Anterior Thoracic (Int: & Ext:)	Pectoral muscle.
	Musculo-cutaneous.	Muscles on front of Humerus, Skin on outer side and front of fore-arm.
	Median.	Muscles and skin on front of arm and fore-arm.
	Ulnar.	
	Internal Cutaneous	Skin on Inner side and front of arm and fore-arm.
Dorsal Divisions.	Suprascapular.	Muscles on Dorsum of Scapula.
	Short-Subscapular (varying in number.)	Subscapularis muscle.
	Circumflex.	Deltoid, Teres minor. Skin on back and outer side of Shoulder and arm.
	Middle Subscapular.	Subscapular & Teres major.
	Musculo-spiral.	Muscles on back of Humerus. Muscles and skin on back of fore-arm and hand.
	Long subscapular.	Latissimus Dorsi.

The position as well as the composition of the Brachial Plexus varies in different animals. It changes when the position of the limb changes. "The Anterior appendage has undergone great changes in position owing to the continual increase in the number of Cervical Vertebræ" (Gegenbaur) and owing to the continual retrogression of the appendages the Plexus has moved farther and farther back from Fishes

to Birds and at last in Man it comes to extend from the lower part of the Side of the neck into the Axilla.

Coming now to the Constitution of the Plexus, we also meet with variations. The most common arrangement is as follows; the 5th and 6th Cervical unite to form an Upper Cord, the 7th is continued as the Middle Cord, while the 8th Cervical and 1st Dorsal unite to form a Lower Cord; each of these three cords divides into an Anterior and a Posterior branch. The Anterior branches of the Upper and Middle unite to form an Outer Cord, the Anterior branch of the Lower becomes the Inner Cord while the three Posterior branches unite to form the Posterior Cord of the Plexus.

A second arrangement is that described by Sir Wm: Turner; the 5th and 6th Cervical join to form a large nerve which is then joined by the 7th to form the Upper Cord of the Plexus; the 8th Cervical and 1st Dorsal unite to form the Lower Cord. From each of these a large branch arises which unite to form a third or Posterior Cord, the Outer Cord being the Continuation of the Upper and the Inner of the Lower Cord.

Other rarer arrangements have been described but these will suffice, and in Studying any of these one will see that they are but mechanical variations and that the Source of any particular nerve may be the same whichever arrangement be taken.

The work of tracing up each of the nerves of the arm to its own root or roots of the Brachial Plexus may be approached from two points of view the Anatomical and the Pathological. The former method has been applied by Krause

and Dr Herringham (Proceed: Roy: Soc: Lond: 1886.); the latter method has not, as far as I am aware, been systematically worked out, but Mr: Thorburn of Manchester, in his recent work on the Surgery of the Spinal Cord, has to a great extent supplied the material required.

Let us take first the Anatomical method. The plan adopted by Krause was to trace the fibres after the Brachial Plexus had been well macerated and Dr Herringham bases his results on 55 dissections, 32 foetal and 23 adult. The results arrived at by these two authorities are, in the main, the same, but Krause, generally, states that a nerve arises from a greater number of roots, and always higher roots, than does Dr Herringham. A comparative table of their results will show this, the nerves only in which they differ being quoted.

Nerve.	Krause.	Herringham.
Subscapular.	5th, 6th, 7th & 8th Cerv:	5th & 6th C.
Circumflexe.	do:	do:
Musculo-spiral	do:	5th (?) 6th, 7th, 8th C.
Median.	5th, 6th, 7th, 8th C & 1st D.	6th, 7th, 8th C & 1st D.
Ulnar.	7th, 8th C & 1st D.	8th C & 1st D.

Dr Herringham has carried his researches still farther and has made out with what root of the Plexus the nerve to each muscle is connected, and as a result has laid down the following laws, which I will here quote; ÷

I. Any given fibre may alter its position relative to the Vertebral Column, but will maintain its position relative to other fibres.

(This law may account for the slight discrepancies in

the table just given.)

With regard to the Motor Supply,

II A. 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.

B. 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.

C. 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.

With regard to Sensation,

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

B. 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.

With regard to the Pathological evidence on this point, it will, I think, be best left, until after the distribution of the nerves in the arm has been considered.

Distribution of Nerves. I. Motor. In reference to the distribution of the Motor nerves to their respective muscles there is nothing to be noted as it is given in any text-book of Anatomy, and on this point authorities are agreed.

II. Sensory. The distribution of the Sensory nerves in the arm and fore-arm may be broadly stated as follows. The inner surface of the arm and fore-arm as well as the adjoining portions of the Anterior and Posterior surfaces, are supplied

by the Intercosto-humeral, the nerve of Wrisberg, the Internal Cutaneous and branches of the Ulnar. The upper part of the Shoulder by the Supra-Clavicular and Supra-acromial branches of the Cervical Plexus. The lower and outer part of the Shoulder, as far as the insertion of the Deltoid muscle by the Circumflex. The outer Surface of the Arm and fore-arm as well as the adjoining surfaces anteriorly and posteriorly by the Internal and External Cutaneous branches of the Musculo-Spiral and the Cutaneous branches of the Musculo Cutaneous.

Front.

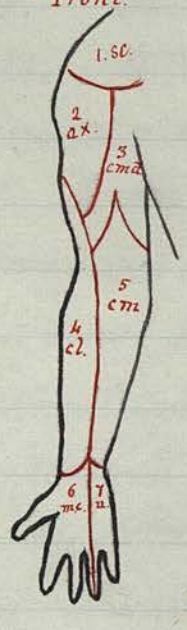


Fig. 1.

Back.

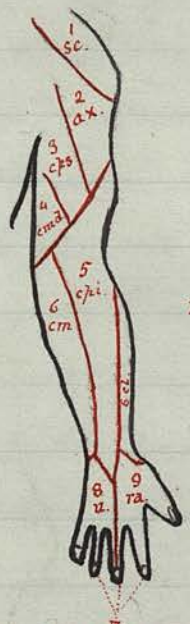


Fig. 2.

From Macalister. p. 279.

1. cmd = Lesser Internal Cutaneous.
2. cm = Internal Cutaneous.
3. cps. } = Cutaneous filaments of
4 chi } = the Musculo-Spiral. N.
5. cl = Musculo-Cutaneous.

The above diagrams taken from Professor Macalister's recent work on Anatomy map out the distribution of the Sensory nerves more definitely.

In the Hand, according to most authorities British and Continental, the Ulnar nerve supplies both Sides of the little finger and the Ulnar border of the ring finger on

both Dorsal and Palmar aspects; while the Median supplies the radial border of the ring finger, both sides of the Middle and Index fingers and the Thumb, on their Palmar aspect; while the Radial has a similar distribution on the Dorsal aspect.

Pathological. I will now pass to the various effects of injuries to the Brachial Plexus and the nerves arising from it, and see how far the truth of the anatomical statements recorded above is borne out.

First, I will refer to 4 cases of injury to the whole of the Brachial Plexus. Dr Ross (Brain. Vol: VII p: 70) records a case of rupture of the Brachial Plexus involving all its roots with the exception of the Communicating branch from the 4th Cervical. In this case every form of sensibility in the Skin of the hand was lost, as also of the fore-arm, with the exception of a small portion adjoining the Elbow in its posterior and internal aspects. The Skin of the Inferior half of the Anterior surface of the Arm was completely anaesthetic, but the Superior half of that Surface, and the whole of the external posterior and internal surfaces of the arm was sensitive, though the Sensibility was diminished, the transition being comparatively abrupt. It is thus evident that the Sensation in these parts must have been conferred by the Sensory fibres of the Communicating branch from the 4th Cervical, (if the diagnosis of the extent of the injury be correct;) the Descending branches of the Cervical Plexus, and the Intercosto-humeral nerve for the small part near the Elbow.

With regard to the muscles, the upper ½ rd: of the Pectoralis ma: the Pectoralis minor and the internal and external rotators

of the Humerus were alone unaffected. Dr Herringham says (Loc: cit:) that the 6th & 7th Cerv: N: roots give origin to the External Anterior Thoracic N: which supplies the upper part of the Pectoralis Major, the middle and lower parts being supplied by the 7th, 8th and 9th, and the Pectoralis minor also from these three roots; moreover, he says that the Lesser Internal Cutaneous takes origin from the 8th Cerv: & 1st Dors: but this case would seem to show that these three nerves must arise from the 4th Cerv: or, at least, that the 2 Anterior Thoracic nerves do so; there may be some doubt about the Lesser Internal Cutaneous as its function may have return-ed, sensation being so often regained long before motion. The External rotators of the Humerus, as given by Sir Wm: Turner are the Supra- and Infra-Spinatus and the Teres minor; the nerves to all these muscles Dr Herringham traces to the 5th Cervical. The Internal rotators are the Subscapularis, Pectoralis, Latissimus D: and Teres major; the nerves of supply to the Subscapularis, he traces to the 5th & 6th Cerv: and the Teres major to the 6th Cerv: the Pectoralis has been referred to. Hence we see that all these nerves, with the exception of that to the Latissimus, do not-confirm Dr Herringham's statements, at least upon the evidence of this one case only, supposing too that the diagnosis be correct.

It may be urged that this case was one of old standing and consequently that there may have been a re-union of some of the nerves, but Dr Ross says (p: 74) "the absence of electrical re-actions in the affected muscles is totally opposed to the supposition that any re-union had taken place". - Granted that

this only refers to the affected muscles, but the Deltoid, Brachialis Anticus, Supinator longus and S. brevis are among these, and Dr Herringham traces the nerve to the Deltoid to the 5th Cerv: and the nerves to the other three muscles to the 6th Cerv: consequently if re-union had taken place so as to allow the non-paralysed muscles to act, why should the Deltoid &c: not act likewise? if Dr Herringham's statements be correct. Krauses results though not in strict accordance with this case, approach more nearly to it.

In a similar case recorded by Maury and Dulring (Amer: Journ: of Med: Sciences. Vol: III. 1874. p: 29) the Brachial Plexeus was excised and consequently the communicating branch from the 4th Cerv: N: must have been divided. Here the anaesthesia extended up the Anterior surface of the Arm to the Shoulder while the Internal, External and Posterior surfaces were sensible to touch. Unfortunately no details are published in this case of the Motor paralysis, but contrasting it with the preceding case one would be led to conclude that the Skin of the upper half of the Anterior surface of the Arm was supplied by the branch from the 4th Cervical Nerve. There is this difficulty to contend with. Mr: Thorburn in his recent work on the Surgery of the Spinal Cord gives two cases (Cases 1 and 2.) in which the injury to the Plexeus was the same as in Dr Ross' case, the 4th Cerv: N: being spared, as was confirmed Post-Mortem. In both these cases there was complete muscular paralysis and anaesthesia below the level of the junction of the upper and middle 1/3rds of the Deltoid, i:e: sensation was limited to the area supplied by the Descending Cervical nerves, the area supplied by the Inter-

cost°. Humeral being also in this case anaesthetic.
Looking at these cases collectively, one sees at once that the results do not agree, and consequently looks for an explanation, and I think one is to be found.
That the communicating branch from the 4th Cerv: Nerve was spared whilst the rest of the Plexus was injured, was verified in Mr: Thorburn's two cases at the Post-Mortem Examination, and the complete muscle paralysis that was observed is in strict accordance with Dr. Herringham's and also with Krauss's results, for neither of these authorities trace any of the nerves supplying muscles to the 4th Cerv: hand. Dr. Ross' diagnosis was not confirmed P.M., but he gives his reasons for it as follows, (Loc: cit: p 74) "The absence of paralysis of the inward and outward rotators of the Humerus would seem to indicate that the motor fibres derived from the communicating branch to the Brachial Plexus from the 4th Nerve, had remained unaffected", but Dr. Ross diagnoses rupture of all the other roots of the Plexus. — I would suggest that in this case the 5th root was also intact and then one would expect the Biceps, Brachialis Anticus, Supinator Longus, Deltoid, Supra- and Infra-Spinatus to be intact (Vide Thorburn Loc: cit: Cases 3 and 9.) and we have seen that most of these muscles were so; with regard to the Biceps, Triceps and Deltoid, Dr. Ross says (p: 71.) "the patient can perform certain movements at the Shoulder joint with the muscles that remain active (viz: upper part of Pectoralis major, External and Internal rotators) which might lead one to suppose, without careful examination, that the

Deltoid, Triceps and Biceps possess a slight degree of motor power," which I would suggest they did.
Dr Ross' opinion was confirmed by Professor Alexander Ogston. One naturally feels very reticent upon expressing an opinion against the diagnosis of two such eminent authorities, but I think the explanation suggested, brings both Anatomical and Pathological facts into harmony.
With regard to the area of anaesthesia in these cases, there is but little help to be got owing (2) to the fact that when some of the nerves to the limb remain intact, the area of anaesthesia soon tends to diminish, a fact which will be more fully referred to later on; and (3) to the fact that in some cases of injury to the Plexus, secondary changes in the Cord supervene so rapidly, and the area of anaesthesia consequently increases, that unless a case is seen and noted at once, it is not of much use; for example Case 3 in Mr: Thorburn's book, there was paralysis below the 5th root; the radial side of the fore-arm and hand & ball of the Thumb were alone sensitive, but four days after the injury there was complete anaesthesia. This case brings out another point of interest; immediately after the injury there was paralysis of all the muscles except the Deltoid, Biceps, Brachialis Anticus and Supinator Longus (Erb's), the Scapular muscles not being examined. Eight days afterwards, the Deltoid became paralysed, which suggests that the Deltoid Nuclei are situated below those for the Biceps, the former having first yielded to the Ascending Myelitis, which was discovered. Post-Mortem. I shall not go through the very interesting

series of cases recorded by Mr: Thorburn, involving the various roots of the Plexus, but I have examined them carefully and I find they are in accordance with Dr. Herringham's paper, which thus proves to be of immense value in the diagnosis of lesions in this region.
I will just refer to Dr. Herringham's first law with regard to Sensation, already quoted; viz: that "Of two spots on the Skin that which is nearer the Pre-axial border, tends to be supplied by the higher nerve" and show how it is confirmed by two cases given by Mr: Thorburn (Cases 3 and 14.) In the former the 4th and 5th roots were intact, sensation remained on the radial side of the fore-arm and hand only, while in the latter case, the 8th Cerv: and 1st Dorsal roots alone were injured and the resulting anaesthesia was confined to the little finger and inner side of the ring finger, the ulnar border of the fore-arm and the internal and posterior aspects of the arm. — In studying these cases one cannot but be struck by the close association of the nerve supply to the Skin and that to the Subjacent Muscles, and, moreover, that there is some close association of these in the Central Nervous System is rendered probable by such cases as that of the man Porey (Charcot: Diseases of the Nerv: System. New Syden: Soc: Trans: Vol: III 1889. p: 261.) who was suffering from Hysterical Monoplegia; it is here recorded that "Sensibility to contact, pain and cold is completely and absolutely abolished, (in certain areas) and this cutaneous anaesthesia exists exclusively in the parts of the extremity (upper) where there is motor paralysis and does not at all follow

the Anatomical distribution of the nerves."
Coming now to the division of individual nerves in the arm itself, we see that the distribution of the Median and Radial nerves to the Skin of the hand, as usually described cannot be correct; and, moreover, that there must be a much more minute anastomoses between the terminations of the various nerves, than is usually mentioned in Anatomical works though Sappey draws attention to it. (Traité d'Anatomie 1871. Tome III p. 431).
Subjoined is a table of 6 cases of injury to the median nerve that I have collected.

Authors & References.	Seat of Lesion.	Area of Anaesthesia.
1. Henriet. Tribune Medicale. 1874-75. III. p. 87.	Median N. at the wrist.	Complete anaesthesia of the Thumb, Indese, Middle & outer half of the ring finger except at the extremity of the last named finger. The whole of the palm was sensible. Dorsal aspect: Anaesthesia of Indese, Middle & outer half of ring finger, but clearly limited to the two terminal phalanges.
2. Rélaton. Gazette des Hôpitaux 1866.	Median in the Upper Arm.	Palmar aspect: As above. Dorsal. Anaesthes: of 2 last phalanges of Middle & Indese Outer Side of thumb more sensitive than inner.

Authors & References.	Seat of Lesion.	Area of Anaesthesia.
3. Leliévant. Traité des sections nerveuses. Paris. 1873. p: 11.	Median at the Wrist.	Anaesthesia of the 2 last phalanges of the Indese & Middle fingers on both aspects. Thumb insensible on Palmar aspect of Terminal Phalanx.
4. Reclus & Fourestié Union médicale. Janvier. 1876 p. 117.	Median and Ulnar at the Wrist.	Palmar. Entire anaesthesia except of Thumb & outer side of the Thenar eminence. Dorsal. Anaesthesia of last 2 Phalanges of the Indese Middle & Ring fingers, but in the last two it extended more into the 1st Phalanx. The sides of the 1st Phalanx of Indese finger were sensible to touch but not to pain.
5. Richelot. Union médicale Mars: 1879.	Median at the Wrist.	Palmar. Diminution of sensation in the outer half of ring Middle & Indese fingers & Thumb. Dorsal. Great diminution of last 2 phalanges of Mid: & Indese.
6. Jonathan Hutchinson. Clincal Lect: & Reports.	Median. Removal.	Sensation only present on the back of the Indese

over.

Authors & References.	Seat of Lesion.	Area of Anaesthesia.
London Hospital. 1866.	of all fingers and metacarpal bones except Thumb and Indese finger.	finger, up to and a little beyond the joint between the first and Second Phalanges.

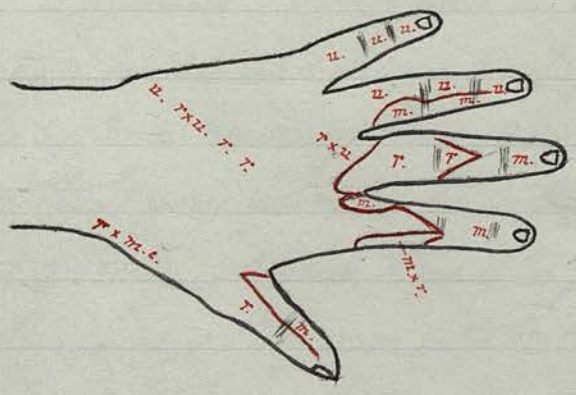
The number of such cases might be greatly multiplied but these I have selected as being so definitely described, and they will suffice to show that the area of anaesthesia is not confined to that part of the Skin alone, which is usually described as being supplied by the Median N: but affects also the Distal phalanges which are usually described as being supplied by the Radial Nerve. Krause, basing his conclusions on the Study of such cases as these, has described the nerve distribution thus; ÷ "Each finger is supplied with two palmar and two dorsal nerves which are derived from the principal nerve trunks to the hand, and run along the Ulnar and Radial borders of the front and back of the fingers. The Palmar are much larger than the Dorsal branches; they run along the inner side of the Palmar Digital Arteries to reach the tips of the fingers and are chiefly distributed to the Palmar surface. Opposite the first Phalangeal joint of each finger, a long branch is given off on each side which passes round the edge of the finger to the back of the Second Phalanx, whilst opposite the 2nd Phalangeal joint, a second smaller branch is given off on each side which also passes round the finger to reach the back of the 3rd Phalanx. These branches divide

without forming a network in the Skin of the end of the fingers and in that under the nail. The Dorsal digital branches reach only as far as the dorsum of the 1st phalanges, where they form loops with the palmar branches; it is only the branch which is distributed to the Thumb alone that reaches to the Ungual Phalanx."

After a study of several cases reported by Mr: Jonathan Hutchinson in the London Hospital Reports 1866, he concludes "that the Digital nerve to the Thumb reaches only as high as the root of the nail, on the Fore-finger to the middle of the Second phalanx and on the middle and Ring fingers not higher than the first Phalangeal joint."

The most recent English work on Anatomy, that of Professor Macalister of Cambridge, adopts this description as the diagram subjoined shews.

Fig: 3.



From Macalister.

Part II.

It will be convenient here to refer briefly to the Physiology of the Sensory nerves, as that is requisite as a basis for the Third Part of this Thesis.

The Sensory fibres emerge from the Spinal Cord by the Posterior roots of the Spinal nerves and upon these roots are situated the Spinal Ganglia. This condition has been stated above to hold good also in Fishes, but in them the Posterior roots were shown to be purely Sensory, and the Anterior purely Motor. In the higher animals it is not so, for though the Posterior are purely sensory, as far as our knowledge at present goes, the Anterior are not purely Motor. Magendi (Journ: de Physiol, 1822) discovered that the Anterior were also sensitive, and concluded that there was no difference between the roots, but Longet (Comptes rendus de l'Acad: des sciences. Juin. 1839. p: 884) first stated that the Sensibility of the Anterior roots was derived from the Posterior and disappeared when the latter were divided. Schiff and Cl: Bernard (Comptes rendus 1847 p: 104 and Leçons sur la physiol: et la pathol: du système nerveux. Paris 1858. II. p: 337 seq:) found that the Sensory fibres in the Anterior root run in a centripetal direction, whereas, those of the posterior roots run centrifugally. This is the reason of the so-called "Recurrent Sensibility" and they found that in order to observe this phenomenon it was necessary that the general sensibility should not be impaired. Moreover, they found that if the animal were slowly etherised Recurrent Sensibility disappeared first, then the Sensibility of the Skin and, lastly, that of the Posterior roots. As the effects of the Ether passed off,

Sensation returned in an inverse order. — This condition is apparently only found in Mammals, as various authorities have failed to discover it in Insects, Batrachians, Fishes or Birds, which explains why I drew attention to the Anterior roots in Fishes being purely Motor.

After the junction of the fibres from the two roots, a mixed nerve is formed and in it the Sensory fibres are carried to the Skin. The relative positions of the sensory and motor fibres in a mixed nerve have not been made out, but in the Embryo Rabbit it has been shown by L. Löwe (Landois & Stirling's Physiology. Vol: II. p: 885:) by the deeper staining with Carmine that the motor fibres take on, that in the Anterior root the Sensory fibres lie in the outer part, the motor in the inner, whilst the reverse is the case in the Posterior root.

The terminations of the Sensory nerves in the Skin with their numerous forms of Touch Corpuscles, as those of Wagner and Meissner, of Vater and Pacini, Krause and Merkel are fully described in all text-books of Physiology and will be omitted here, but it will be convenient, with reference to what will follow, to say a few words descriptive of the way in which the Sensory nerves terminate in the Skin by the formation of a Plexus. "When Sensory nerve fibres terminate in Plexuses, they generally branch once or twice on nearing their termination. The sheaths of the fibres then successively become lost; first, the Peri-neural sheath, then the Medullary sheath and, lastly, the Primitive sheath, the Axis Cylinder, being alone continued as a bundle of primitive fibrils. This branches and joins with the ramifications of the Axis Cylinders of neighbouring nerve fibres to form a Primary Plexus. From the

Primary Plexus smaller branches come off and these form a Secondary Plexus nearer the Surface, generally immediately under the Epithelium. Finally, from the Secondary Plexus nerve fibrils proceed and form a terminal Plexus or ramification amongst the Epithelial cells, the actual ending of the fibrils being generally in little knob-like enlargements." (Schäfer's Essentials of Histology. 2nd Ed: p: 83.) We are still ignorant of the molecular mechanism of nerve endings.

It has long been a vexed question amongst Physiologists to determine exactly the point where the Sensory fibres in a mixed nerve turn back in a centripetal direction to give rise to Recurrent Sensibility. Claude Bernard (Lec: cit: II p: 28) found that after division of a mixed nerve, the Antrin part was insensible and consequently concluded that the recurrence of the Sensory fibres probably takes place at the periphery possibly through such a plexus as that just described.

Functions of the Sensory Nerves. The function of the Sensory nerves is to carry sensory impressions from the periphery to the Central Nervous System: These impressions are of various kinds as Touch, Pain, Pressure, Temperature, Locality, Tickling etc. As to the mode of transmission of these various impressions, there is much difference of opinion, some authorities affirming the existence of different sets of fibres for the different impressions, whilst others deny it and maintain that all impressions are carried by the same fibres, but that the various stimuli bring about, in each, their own molecular changes in the nerve, which are capable of being discriminated by the Brain. Let us examine the arguments adduced by the advocates of these two theories, taking the latter first. Dr Weir Mitchell

in his book on "Injuries of Nerves" (p: 39) says "The phenomena of nerve injuries tend to discredit by negative proof the theory of the existence of numerous sets of sensory nerve fibres" and he goes on to say that as all the internal organs are supplied by sensory fibres of which some must be pain conducting and may perhaps only be roused into activity once in a life time, it is difficult to understand how, being so rarely used, they can sustain their organic life uninjured and ready to awaken into functional activity at long and irregular intervals. "I am unwilling," he says (p: 40) "in view of these facts, to look upon pain as a distinct sense with afferent tracks peculiar to itself; and when we consider also how sensory impressions, made on nerves purely of special sense, may rise to the height of being painful, it becomes more and more probable that pain is a central expression of a certain grade of irritation in any centripetal nerve." Again (p: 192) he says "The sense of temperature is lost with that of pain and touch" (as if pain and touch were always lost together) "and usually in a like degree. I have never seen it altered from nerve wounds without affection of the pain and tact sense. Neither have I met with any case of nerve wound which seemed to involve loss of muscular sense". But the same author gives two cases in his "Report on Nerve Wounds" (Cases 27 and 28.) which do not quite bear out what I have quoted above; for in the first of these cases, a wound of the arm, there was a great diminution in the sense of pain, with no loss of touch; and in the second, the loss of the pain sense was so great that the electric wire brush was scarcely felt and this was accompanied by hyperaesthesia.

Again, Mr: Bowlby of S. Bartholomew's Hospital, in his recent work on "Injuries and Diseases of Nerves" (p: 14) says "There is really no reason why the same nerve fibres should not be capable of conveying various impressions which can be appreciated by the nerve centres. We know that the contraction of a muscle can be excited by the application of various irritants to its motor nerve, and as far as I am aware, no one has yet suggested that each stimulus requires a separate set of fibres to produce its due effect." But I do not see that the analogy holds good; for in the first case each different cause produces the same effect, viz: muscle contraction, but in the case of sensation, each cause produces its own particular effect. If the cases were analogous, the right inference to draw would be, that the various sensory stimuli would all produce one and the same impression in the Sensorium, which is clearly not the case.

The advocates of the opposite theory, viz: — separate tracts for the separate stimuli, are much more numerous.

In Landois and Stirling's Physiology (Vol: II p: 1150,) it is stated that the nerve trunks contain two functionally different kinds of nerve fibres (α) those for transmitting painful impressions, and (β) those for Tactile impressions which include Temperature and Pressure impressions; and the facts adduced in support of this are (i) Tactile sensations are absent from all internal viscera; pain can alone be discharged from them; (ii) Probably the reflex acts discharged by both sets of fibres are under the influence of special central organs; (iii) One sensation may be abolished and the other ~~abolished~~ by ~~increased~~ retained or even increased under pathological conditions,

as and under the action of narcotics; and (iv) the different course of the fibres in the Spinal Cord.

Strong as these arguments are, I think the division of the Sensory fibres into two sets only is not enough; and, moreover, the Temperature-sense fibres can hardly be identical with the Tactile, since the impressions of pain and temperature are transmitted by deeper portions of the cord than are the ordinary tactile impressions. (Professor Grainger Stewart. Lectures on the Nervous System. p: 7.)

The researches of Blisc (Zeitschr: f: Biologie: Bd: XX p: 141) Eulenberg (Zeitschr: f: Klin: Med: B IX. Hefft: II.) Hensen and Goldscheider show that on the cutaneous surface there are temperature spots, i:e: little areas in which sensations of heat and cold are more acutely felt than in adjoining areas; some cold spots, others heat spots; the former are the more numerous; both are sensible to pressure; irritation does not produce pain. "No terminal organ for temperature has yet been discovered" (M^c Kendrick. Text-book of Phys: p: 653.) Here we see that the Temperature spots though sensible to pressure, are not to pain, which is probably due to conduction by different nerve fibres, though as we have seen above, they are in the same spinal tract. Moreover, D^r Gowers (Diseases of the Nerv: Sys: Vol: I p: 8.) says that there is strong reason to believe that the Sensibility to heat and cold ~~are~~ is subserved by different nerves, which is quite in accordance with the presence of the Cutaneous heat and cold areas.

I have as yet not be able to find any evidence for separate sets of fibres for the Conduction of Temperature and of Pressure, though they may exist, but the fact of the Temperature spots

being sensible to pressure, tends rather to disprove it.
Consequently, I would divide the Sensory fibres into :-

(i) Tactile.

(ii) Pain

(iii) Pressure and Temperature { α. Cold. β. Heat.

There is no evidence of special fibres for conducting the impressions of Locality and Tickling; the latter is possibly a simple Tactile impression on a somewhat hyperæsthetic End Organ. The impression of Locality, I believe to be purely a function of the Brain, because in a young infant, though the functions of the Pain, Tactile and Temperature conducting fibres are all active, as are also the fibres conducting the Special Sense impressions, yet it is some months before the child can tell the direction from which a sound comes and look towards the place; and, again, if you touch a young child's hand, before it has noticed your presence, thereby stimulating its tactile fibres, it will as often as not look for the exciting cause in a wrong direction. Hence, if the other Sensory fibres are functionally active, why are not those of Locality, if there be separate fibres for that particular kind of impression?
Having thus classified the Sensory fibres, let us see whether this classification receives the support of Clinical observation, and I think it does. We find it borne out by the two cases of Dr Weir Mitchell's already referred to (p:25) Cases 27 and 28. in his "Report on Nerve Wounds" and also by the case by Reclus and Fourestié. (Case 4 in the table on p: 19 of this Thesis.). In a forthcoming paper by Professor Blocq: of Paris on Syringomyelia, he says that in this disease sensibility to Pain, Heat and Cold are affected, while the Tactile sense is not:

In a very interesting case of Acute Atrophic Spinal Paralysis recorded by Dr Ross (Practitioner. Vol: 29. 1882.) we find three different conditions in the different parts of the body; viz;-

Left Extremity.	Tactile Sense	Normal.
	Pain "	Abolished.
	Thermal "	Abolished.
Right Extremity.	Tactile "	Normal
	Pain "	Hyperaesthetic.
	Thermal "	Diminished.

From the 2nd to the 10th Pulse all three were abolished.

It is only, I think, by the Study of cases such as these that one can really settle the question, as a stimulus applied directly to the nerve endings may produce a sensation which cannot with any degree of decision be defined by the individual, as a slight Thermal impression may produce at the same time a Tactile impression, and either may very easily become painful.

During the time that I was Clinical Assistant in the Electro-therapeutical Department at S. Mary's Hospital, under Dr A. D. Waller, I worked at the Subject of alterations in the Electrical Excitability of the Cutaneous Nerves in health and Disease, especially in the cases of Locomotor Ataxia, of which there were a number for suspension-treatment, but even working in the lines set down by Drs Tschirjew and Dr Waller (Brain Vol: II. 1879-80.) for overcoming variations in the resistance of the Skin, owing to the great differences in the excitability in healthy people, but more especially to their inability to define with any exactitude their various sensory impressions, I was quite unable to come to any satisfactory conclusions on the Subject as afforded by the Electrical test.

Part III.

In dealing with the Pathological relations of the Nerves, I shall not enter into the Microscopical changes taking place in cases of injury and disease of the nerves, as it would in great part be a mere recapitulation of the results of the researches of A. Waller, which are now so well known, but I shall devote myself chiefly to the so-called "Subjective Symptoms" or alterations in the normal Physiological functions, and I shall begin with one of the most frequent, viz: ÷

Anaesthesia. This term though literally meaning loss of sensation, is more generally restricted to mean loss of the Tactile sense. The cause may be Central, Peripheral, i.e: in the nerve terminations, or Intermediate, i.e: in the course of the nerve trunks.

i) Central. This may be either in the Brain or Spinal Cord, and is then chiefly due to pressure upon the Sensory Centres or the Sensory Conducting Tracts. The pressure may be due to Tumours, Abscess (though in this case the Anaesthesia is not usually a prominent symptom.) or Hemorrhage. In the last case the Hemorrhage may be preceded by Cutaneous anaesthesia, probably due to some disturbance in the Cerebral Circulation. Inflammatory and other lesions of the Spinal Cord and its membranes may give rise to this Symptom, as is seen in Locomotor Ataxia; these are also, doubtless, due to alterations in the circulation or to pressure from the Sclerosis.

But Anaesthesia of Central origin may be Psychic as in the recent numerous exhibitions of Hypnotism; or, Functional as in Hysteria, in which case the affected site may vary

from time to time. Dr Savage (Insanity p: 291) states that Local Anaesthesia is very common in cases of General Paralysis of the Insane; this, too, is probably of central origin and due to degenerative changes.

It may also be caused by drugs, as by the inhalation of Chloroform, and in the later stages of the toxic effects of Cannabis Indica, Dr Binger (Therapeutics p: 521) says that there is such complete anaesthesia, that, while standing there is no consciousness of touching the ground.

(ii) Peripheral. May be due to Pathological changes in the Nerve terminations, as in Herpes Zoster, in which disease the Skin between the Vesicles is often anaesthetic, and according to Bendu (Journ: de Dermatologie. T VI No1. p: 37.) the anaesthetic areas are surrounded by zones of hyperaesthesia; the anaesthesia may persist after the cicatrisation of the Vesicles. This may probably be due to nutritive changes.

Again, there is a similar condition in Elephantiasis Anaesthetica; here, according to Boeck and Danielssen (Quain's Dict: of Med:) the Sheaths of the cutaneous nerves are thickened and distended with exudative products. It also occurs (Bendu. Loc: Cit: p: 166) in Psoriasis scarlatiniformis and is a point in diagnosis; for in this form there is anaesthesia with analgesia; in P: circin: the reverse is the case and in P: guttata (Fr:) there are no functional Symptoms.

The peculiar condition, the Anaesthesia Dolorosa of Romberg, must be mentioned in this connection.

Peripheral Anaesthesia may be produced by the local action

of various drugs, but we can not well separate this condition from Peripheral Analgesia as the agents are used surgically to produce the latter effect.

Carbonic Acid was first mentioned by Ingenhousz (Miscellanea physico-medica. 1794 p: 8) as having local anaesthetic properties. Thomas Beddoes states that having had the Skin taken off his finger by a blister, the pain which he felt on exposure to the air was relieved by putting it into CO_2. (Considerations on the medical use and on the production of factitious airs, by Th: Beddoes and James Watt. 1795. p: 43.) Similar applications of this gas were made by Broca, Verneuil and Sir James Simpson.

Carbonic Oxide (Coz. Comp. rend: Mars 2^{ie} 1857) Ether Aconite, Cold all produce local anaesthesia, the part becoming blanched and anaemic and both anaesthetic and analgesic. Cold probably acts by the intense anaemia it causes; Warmth, on the other hand causes hyperaesthesia. How these Substances act is not quite clear, it may be by their chemical properties acting directly on the nerve endings, or by altering the circulation, causing anaemia and consequently lowering the nutrition of the nerve endings and depressing their functional activity.

(iii) Intermediate. In all these cases there is an interruption of the tactile impressions as they pass centrifugally. This interruption may be more or less complete, the whole nerve being divided or only certain strands, as in punctured wounds, or to changes in the Substance of the nerve itself, to pressure from without or to Contusion.

Cases due to pressure from without are not infrequent; the pressure may be due to tumours of various kinds as Exostoses, or to dislocation of a bone coming to press on a nerve trunk of which Duchenne in his L'Electrisation Localisée relates some cases, there being dislocation of the head of the Humerus causing loss of sensation. The initial loss of sensation was due probably to the pressure preventing the conduction of the nerve impressions to the centres, but if the dislocation be not reduced, the constant pressure could cause anaemia and atrophy of the nerves and bring about a permanent anaesthesia as far as that nerve was concerned. That this loss of sensation was caused by concussion and compression and not by a laceration of the nerves was proved Post mortem; indeed, Malgaigne states that he has never been able to produce rupture of the Brachial Plexus on the dead body, no matter how much traction be put on the upper limb, and he has never seen it, post mortem, from dislocation of the Humerus in any of the cases that he has examined. That such a rupture of the Plexus is possible from traction during life is evidenced by the case recorded by Dr. Ross (Brain. Vol: III p: 70) to which I have already referred. Compression of a nerve trunk used formerly to be resorted to as a means of producing local anaesthesia for surgical purposes.

Vulpian and Bastien (Comptes-rendus. 1855 p: 1009.) have studied the phenomena of nerve compression, and they divide it into two periods, one of advance and the other of decline, in each of which are four stages.

The 1st stage of the advance period, is marked by Jomication and tingling; the 2nd (Intermediary) stage, in which there is a return to the normal; 3rd stage of hyperaesthesia, and the 4th of Anaesthesia, being accompanied with muscular paralysis. The period of decline has these four stages but arranged in an inverse order.

A. Waller (Proc: Roy: Soc: London. May 15th 1862.) has verified these results, but in addition has pointed out that when a single nerve has been compressed, the spinal muscle paralysis is not confined to the muscles alone supplied by that nerve, this is in accordance with the clinical experience of Duchenne, Weir Mitchell and others.

For an explanation of this fact we must look to the conclusions of Remak, Erb, Ferrier and others, that the grouping of the motor cells in the Spinal Cord depends on the Physiological association of muscles in the production of certain movements and not on the mere anatomical fact of their being supplied by the same nerve trunk; and, moreover, that a muscle concerned in different sets of movements is connected with correspondingly different sets of nerve cells in the Cord, hence compression of a nerve going to a certain muscle may give rise to disturbance in the various sets of nerve cells with which that muscle is connected and this disturbance may radiate to the neighbouring Spinal Motor cells and consequently affect the muscles over which they preside.

Contusions may also cause anaesthesia, but in these cases from an alteration in the nerve tubules, probably from a breaking up of their Axis Cylinders.

Cases of anaesthesia from contusion without any apparent traumatic lesion are on record, one by Weir Mitchell from a strain of the wrist (Injuries to Nerves. Case 7. p:96.) and another by Lamothe (Oeuvres chirurgicales. Vol:II p:617.) in which a blow, from a billiard cue, on the shoulder, caused entire loss of sensation in the arm for fifteen days.
Changes in the nerve trunks. Changes in this position giving rise to the loss of the tactile sense, are not very common. Anaesthetic areas are found in cases of long continued Neuralgia, but according to Dr. Buzzard (Quain's Dict: of Med:) and to the experience of many, neuralgia, if not of long duration, is accompanied by hyperaesthesia. With regard to the Pathology of Neuralgia little is known, but according to the same authority (Loc: cit:) the nerve trunk is sometimes found swollen and hyperaemic; or, in a later stage it may be atrophied and degenerated, and the atrophy would be associated with anaemia.
From what has been said it appears that anaesthesia is caused by anaemia, excluding, of course, all those cases where there is solution of continuity in the nerve, or destruction of nerve tissue, for all cases due to pressure may be looked upon as cases of local anaemia of a nerve and through which the ordinary tactile impressions become perverted; so also, in Neuralgia we have seen that the stage of anaesthesia is associated with an anaemic condition of the nerve.
In support of this conclusion, there is a certain amount of experimental evidence. Dr. Weir Mitchell (Loc: cit:) applied ice and salt over his own Ulnar Nerve, at the Elbow,

in order to freeze it; the first effect is an aching pain, but after a time, there is total anaesthesia in the area of distribution of that nerve; of course, the nerve was not afterwards examined, but we may fairly conclude that the prolonged freezing would cause anaemia, as the nerve in this situation is so superficial; had it been deeply seated one might expect an opposite condition.

We now come to loss of sensation due to a solution in the continuity of a nerve trunk; this may be partial or complete, as the nerve is partially or entirely divided.

The cause of the loss of the Tactile sense is here self evident, but I shall pass to some of the considerations which division of a nerve brings under our notice; they are,—

(a) Anaesthesia does not supervene immediately, in all cases, after the infliction of the wound.

(β) The affected area does not always correspond with the anatomical distribution of the nerve.

(γ) The area of anaesthesia tends to diminish with lapse of time.

(δ) Sensation may be but little affected though there be complete muscular paralysis, and it is re-established sooner.

(a) Where a nerve of mixed function is slightly injured, the first impression is most felt by the Sensory fibres, and any motor loss is apt to be due to secondary changes; but, in more serious lesions motion and sensation are both lost at first.

But that the loss of sensation may not supervene directly

after the infliction of an injury and may be preceded by motor paralysis is shown by the case of Dislocation of the Humerus recorded by Duchenne (Loc: cit: Case 29.)
However, some of the cases where loss of sensation has been delayed may possibly not have been most perfectly examined, especially if the injury has been to a single nerve trunk, as in these cases complete division may take place without causing complete anaesthesia in any part of the area of distribution of the Sensory branches of that nerve, a fact, to the consideration of which, we now pass;
(β:) That the affected area does not always correspond with the supposed anatomical distribution of the nerve, may be due to two causes; (i) the Anatomical distribution of the nerve may have been improperly known and described, as has been shown to have been the case in Part I of this Thesis, with regard to the Cutaneous nerves of the hand; and, (ii) the over-lapping, as it were, in the terminal distribution of nerves, so that when one nerve is injured, another is able to carry on the Sensory function over the area principally supplied by the injured nerve. This is shown clinically to be a fact, by two cases observed by Letiévant (Traité des sections nerveuses. Paris. 1873. p: 70.) of complete division of the ulnar nerve with paralysis of the muscles supplied by it, but the loss of sensation was only complete over a small patch on the ulnar border of the hand, the remaining portion of skin supplied by that nerve being only incompletely anaesthetic.
This fact is also confirmed by the Experiments of Arloing and Tripier (Archiv: de Physiol: normale et pathologique.—

III. pp: 33 and 307.) who found that division of one or even two of the nerves supplying the digit of a dog ~~of~~ or cat, caused but little diminution in the area of sensibility; and that it was only when all four nerves were divided that complete anæsthesia resulted. Again, they found in the fifth digit of a dog, which is supplied by branches from the Radial and Ulnar nerves, division of one nerve causes only partial, but division of both, complete, anæsthesia. Division of the Ulnar nerve alone, in the cat, causes complete anæsthesia of the fifth digit, as it is only supplied by that nerve.

This inter-dependence of the nerves is probably brought about through the free anastomoses between the terminal filaments of neighbouring nerves, as I have described above in speaking of nerve terminations (Part: II.), or possibly by Recurrent Sensibility, as Arlong and Tripier think, acting through these anastomoses.

This brings us to the third consideration; viz: ÷

(3.) The area of anæsthesia tends to diminish with lapse of time. This may be due to reunion of the ends of the divided nerve. This union may possibly be by "first intention," though it is doubtful, and sensibility restored within a few hours as in a case recorded by Laugier (Bullet: de la Soc: de chir: Juin 1864.). Weir Mitchell (Loc: cit: p: 239.) throws doubt on this case owing to the unsatisfactory way in which the sensibility to touch was tested, and quotes Tillaux, who says that since this case both Nélaton and Verneuil have both used the Suture in divided nerves, but without even an approach to the success above recorded.

Though Ch: Richet seems to have no doubt as to the union by first intention and quotes several cases in support of it, (Recherches experimentales et cliniques sur la sensibilité Paris 1877. p: 23.), I am inclined to agree with Dr. Mitchell because I doubt whether it is possible for so rapid a restoration of function, and secondly, even if properly tested, as I have said, division of a single nerve trunk does not cause complete anaesthesia of the part it supplies, as is shown by a case given by A. Richet (Union medicale. 1867. T II. p: 270) where the median nerve was divided and the sensibility of the parts supplied by it was intact, and similar cases are recorded with regard to the Ulnar Nerve by Progoff (Military Surgery: p: 377.)
That a restoration of function is ultimately brought about and it may be, hastened, by suture is within the experience of most Surgeons, even after the division has taken place for 16 months or longer. In all these cases motion is not restored until after sensation has for some time returned. Here we are brought to a point much debated upon by physiologists. There is no doubt that motor nerves will unite with motor and sensory with sensory with restored functions, but will sensory unite with motor nerves? Paul Bert made the following experiment: he stitched the tail of a rat into the animals back and after union had taken place, he cut the tail from the body at the root, so that the tail, as it were, grew out of the animals back, broad end uppermost. On irritating the end of the tail, which was formerly the root, the animal gave signs of pain. This experiment shows that nerve fibres can conduct impulses

in both directions. One of two things must have occurred. Either the motor fibres which normally carry impulses down the tail, now convey them in the opposite direction, and convey them to Sensory fibres with which they have united, or the Sensory fibres must have united with Sensory only and convey impulses in an opposite direction to normal. Bickert asserts that he has succeeded in uniting the Hypoglossal with the Vagus Nerve in the dog. (Landois and Stirling's Physiology. 2nd Ed: Vol: II. p: 787.)
That the area of sensibility may diminish without any such union is seen frequently clinically, and is, I think, due to neighbouring nerve terminations taking on an increase of function, what may be termed a function of Compensation analogous to what is observed in the opening up of a Collateral Circulation.
(iv) That Sensation may be but little affected though there be complete muscle paralysis, is shewn by the case given by A. Bickel, quoted above, in which there was paralysis of all the muscles supplied by the Median, and only a very transitory loss of sensation; and also by other cases recorded by Weir Mitchell (Loc: cit: Cases 35 and 36. pp: 207 and 209.)
This is also explained either by the function of compensation, or by Recurrent Sensibility, or by both factors acting together.
That Sensation is restored before motion is, I think, acknowledged generally, at any rate, we have the authority of Prioseff & Weir Mitchell, and in explanation of this fact I cannot do better than quote the latter authority; ÷ (p 190)
"When a function is partially paralysed, its continued exercise is one of the conditions of its ultimate return to

full activity so soon as the neural injury has become repaired. The sense of touch is in constant automatic use, every contact being a continued stimulus to its activity, and the very fact of deficient feeling subjects the part to rough and unusual irritations. ..... But when muscles are partially paralysed, an effort of will, greater than common, is demanded to take them into action. The early inflammatory conditions make motion painful. The effort is unusually wearisome, and there is no inevitable and constant stimulus, such as exists in regard to touch. Hence, perhaps it is that motility is regained less easily than Sensibility.

I now pass to the consideration of the opposite condition; viz:- Hyperæsthesia or increase in the Tactile Sensibility, and in discussing this Symptom it is almost impossible not to include in this term, such other conditions as Hyperalgesia, as in Hyperæsthetic conditions the slightest touch may give rise to pain. Dr Buzzard thinks it is doubtful whether the Sense of touch proper, the power of tactile discrimination, is ever morbidly increased except possibly in certain cases of Hysteria and mental disorder, and moreover that it is rarely observed clinically and is of but little Clinical importance.

Cause & may be

(i) Central as in Hysteria; in mental disorders it is less frequent being most common in General Paralysis, and even in this disease it is far less common than anæsthesia. (Dr Savage. "Insanity". p: 291).

It is also sometimes seen in the early stages of febrile conditions and in Inflammatory affections of the Central Nervous

System. At the upper limit of an inflammatory lesion in the Cord, either traumatic or idiopathic, there is often a zone of hyperæsthesia; the cause being probably due to a congested and irritable condition of the neighbouring sets of Sensory cells in the Cord. This grouping of Sensory cells in the Cord, and to which certain curious phenomena, such as the pain, in Angina Pectoris, in the left arm, may possibly be due, is discussed at length in a most interesting paper by Dr. Sturge on "The Phenomena of Angina Pectoris, and their bearing upon the Theory of Counter-Irritation" (Brain. Vol: I. Pg: 492.)

Peripheral. Here the cause of hyperæsthesia frequently lies in the various forms of Inflammation of the Skin, & was a very marked symptom in a case I have seen recently of Cellulitis in the lower 1/3rd. of the Thigh.

According to Dr. Binger, in the early stages of the toxic effects of Cannabis Indica, pressure on the Skin may cause a sense of burning, which may be looked upon as a form of Hyperæsthesia.

Intermediate. Some of these causes have already been incidentally mentioned. It has been seen that Vulpian and Barlow state that Hyperæsthesia is the characteristic of the 3rd stage of nerve compression; it is also frequent in the early stages of neuralgia, coincident with a swollen and hyperæmic condition of the nerve.

This subject cannot be further considered apart from the Subject of Pain, with which it is so intimately associated; but I have, I think, said sufficient to shew that I believe Anæmia of the nerve tissue to be the immediate cause of

Anaesthesia, be the cause Central, Peripheral or Intermediate, and that Hyperaesthesia is caused by a Congested condition of the nerve fibres in some part of their course.

Pain is the most common symptom of nervous lesions of all descriptions. As nerves vary in their excitability, so different beings vary in their susceptibility to pain. Brown-Séquard has noticed that men and animals of the New World bear pain better than those of the Old World; so also the more uncivilised bear pain better than the more civilised, for we have all heard of the African women, falling out of the ranks of a slave gang, being confined alone by a secluded stream, in which to wash the infant, and then immediately rejoining the gang and continuing the march. So also in every day experience, we notice that in the lower ranks of life, women seem to suffer less at such a time, than those in the higher walks of life; this, I think, must surely be from a difference in nerve sensibility probably due to a higher development of the Sensory Centres in the Brain.
Of course, in Man, the will plays an important part and due allowance must be made, but there must be something apart from this, for physiologists tell us that all frogs do not bear the same sensory excitations in the same way, and that in winter, sensation in frogs is so dulled that one can practice on them all kinds of vivisection which it would be impossible to do in warmer weather (Le Ch: Richet- Loc: cit: p: 238.) Thus we see that,

in dogs at least, the excitability of a nerve is not always the same and consequently we are led to think that the state of the nerve plays an important part in the acuteness of the pain which a certain impression may produce, and of this there is both clinical and experimental confirmation, for we all know how exquisitely sensitive inflamed structures are, as bone for example; and, moreover how much more painful is an incision into inflamed skin than one into healthy skin; a still more curious fact is, that sensibility may return in an anaesthetic area if it become inflamed, as is seen sometimes in cases of Leprosy (Guyon. Comptes. rend: T63. 1856. p 900) It has been shown by Haller and Flourens (Mém: sur la nature des parties sensibles et irritables II. p: 136. and Comptes-rend: T43. p: 642 and T44 p: 804.) that the healthy Dura Mater is insensible but if inflamed is very sensitive, and with regard to the reflex action of pain Tarchanoff (Gazette medicale. 1875.) has shown that whilst it is not possible easily to arrest the Hearts action by exciting the mesentery of a dog, it is possible when that membrane is inflamed by exposure to the air for some time.

Another example, is one of every day experience, I mean the pain of joint and Ligament injuries, Sprains and inflammatory conditions of the tendons, all of which tissues were at one time supposed to be practically extra-neural.

As to the seat of origin of the pain, it may be,

ii) Central. This requires no mention, but there are two curious forms of pain, seen in cases of Locomotor Ataxia, which

deserve a passing mention, they are the Lightening and Girdle pains. Of the former, I am able to offer no attempt at an explanation; the latter are probably due to gradual contraction of the Sclerotic Fibrous Tissue which surrounds the point of entrance of the Posterior Sensory Nerve Roots into the Spinal Cord.

The pain which is sometimes due to Shock is also of Central origin. In many cases where the pain is undoubtedly of Central origin, it is often referred to the periphery, as in these Girdle pains, and in the Aura of Epilepsy, in which a spontaneous disturbance begins in the Sensory part of the Cerebral Cortex, and yet Various sensations are felt at the Periphery in the absence of any outward disturbance to correspond with them.

Peripheral. Pain may be produced peripherally by Various inflammatory affections of the Skin involving the nerve terminations, or the nerve terminations themselves may be primarily affected as in Peripheral Neuritis, or by an excessive stimulation as by blistering.

or, Intermediate. There may or may not be any solution of continuity in the nerve trunk, as in puncture or division of the nerve, or where there is Contusion, Congestion or Inflam-ation of a nerve.

Pain may be of various kinds as aching, tearing, burning boring etc: but there seems to be no relationships between the character of the pain and the nature of the wound; but where there is no solution of continuity of the nerve, the pain is more usually of the aching and tingling kind, unless secondary changes give rise to the pain of Neuritis.

There is a peculiar intense burning pain which is very frequently associated with a glossy condition of the Skin to which Dr. Weir Mitchell has given the name, Causalgia; it rarely arises at the moment of wounding but almost always during the healing of the wound. The cause is unknown but it sometimes follows the transfer of pathological changes from a wounded nerve to unwounded nerves and has been felt in their distribution. It most frequently attacks the hands and feet, rarely the ~~hands~~ arms and ~~feet~~ legs, never the trunk.

Pain is often not felt at the moment of infliction of a nerve injury and if it does it rarely persists. In 91 cases of nerve injury collected by Dr Weir Mitchell, pain followed immediately in rather less than two-thirds of the cases, and in only one of these did it persist, in the remainder it passed off leaving a sensation of tingling and numbness. Pain may be caused by simple pressure, but is apt to be more severe if the pressure varies; acute pain due to pressure is frequent in cases of Aneurism. In many punctured wounds there may be pain and hyperæsthesia, which may grow worse if Congestion of the nerve, and hyperplasia of the Inter-neural Connective Tissue supervene. Pain, from nerve injury, may be Constant or Intermittent, "The neuralgias common to all Nerve injuries are apt to assume a quotidian type, and, as a rule, occupy the later rather than the earlier hours of the day," thus differing from Causalgia (W. Mitchell. Loc: cit: p: 195.) and may probably be due to stimulation of the Circulation from exercise. A curious case, related by Mr: Swan, and referred to

by Dr Weir Mitchell, of an ulcer over the Peroneal nerve, occasioned a pain which recurred daily at the same hour. Pain is usually, as has been said, referred to the terminations of the injured nerve or may even be referred to remote parts, without any pain at the point of injury, a condition known as Allochiria. After an amputation pain is commonly referred for some time to the limb that has been removed, injury to the Sciatic Nerve may cause pain and retraction of the Testicle, and Dr Weir Mitchell says that in many cases of neck wounds great pain has been felt at the insertion of the Deltoid muscles, and he suggests that it may be due to Spasm, but Spasm would not account for a case, such as the one given by Professor Annandale (Malformations of Fingers and Toes. Case 35.) in which the pain was felt in the right hand and in the Soles of the feet, though the injury was to the ring finger of the left hand.

Possibly some explanation may be found for it in the physiological grouping of Sensory cells in the Cord, similar to that for the motor Cells, and when one group of cells becomes irritated through fibres from the periphery, the irritation radiates to neighbouring groups of cells, which themselves becoming irritated, refer the irritation to the periphery of the nerves over which they preside.

Pain may cause reflex muscular contractions especially in the muscles innervated by the Facial nerve. Stimulation of the Central end of a Sensory nerve, causes elevation of the Blood tension and a lowering of the pulse rate (Ch: Richet- Loc: cit: p: 239.). The effects of pain may also become exi-

dent by alterations in the intellect, it may be in severe cases by permanent loss of reason.

In speaking of the disorders of the Tactile sensibility I spoke of the condition known as Allochiria, that is the condition in which the sensation is felt on the opposite side of the body to the one touched and I referred to a case of Professor Annandale's in which this symptom existed, but I omitted to mention the two conditions known as Polyaesthesia and Dysaesthesia.

In Polyaesthesia, a single impression is felt as two or three, and Professor Grainger Stewart gives a good example of it (Loc: cit: p: 69.) These multiple impressions according to Dr Gowers, are usually all felt in the same limb.

Dysaesthesia or Paraesthesia, was first described by Charcot. In this condition a touch may give rise to pain, or both tactile and painful impressions may produce sensations abnormal in character, as thrilling, tingling etc: in the limb touched.

These conditions are of very rare occurrence, and as so little is known of them, I will not dwell upon them any longer.

Temperature Sense. On this subject I have little to add to what has already been said in Part II. Sensibility to temperature is usually affected with that of pain, but often not in the same degree, or, one may be affected without the other. There may be absolute

inability to recognise heat and cold, as such, or only when there is a wide range between them is any difference perceived; or, again, heat may be felt as cold, and cold as heat: The sense of Temperature is always slightly delayed, even in health, owing to the Skin having to be heated, or cooled, before the nerve terminations commence to receive the impression. When perception of pain is delayed, that of temperature may be much delayed also.

Retardation in the Conduction of Impressions. In various conditions the impressions may be delayed, any or all being affected. I shall not say more on this Subject, as it occurs solely in lesions of the Central Nervous System. Dr Weir Mitchell says, (Loc: cit: p: 225.) that "even in the gravest lesions of nerve trunks, if a touch were felt at all, it was felt with no remarkable delay.

Leaving now the Subject of alterations in the Cutaneous Sensibility, I pass next to the

Muscular Sense which is due to the Sensory Nerves with which muscles are so abundantly supplied and which end, according to Tschirjew (Archiv: für Psychiatrie. Bd: VIII Hft-3.) in the Interstitial tissue between the muscular fibres. This sense may be exalted or diminished "It is conceivable that loss of muscular sense may result from lesions of the nerves, but I have not yet seen proof of this." (Grainger Stewart: Loc: cit: p: 72.)
In every case that alteration of this sense has been observed, of which I have been able to find any account, there has

been some Central lesion, as Locomotor Ataxia, consequently I shall not touch further on this Subject.

Paradoxical Muscular Contraction. Under this name Westphal has described a curious condition, sometimes, though rarely seen in nerve lesions. It is a slow tonic contraction in a muscle when suddenly relaxed, or its course suddenly shortened. The mechanism is uncertain, and it is but rarely seen in the Arm.

I now pass to say a few words on some of the more remote symptoms sometimes seen in lesions of the nerves of the Upper Extremity, and I shall commence with the Trophic Changes in the Skin and its Appendages.

(i). Herpes Zoster. Vesicles and Bullæ may occur arranged in groups, which may occur in successive crops, along the course of the nerve. In the British Medical Journal (April 26. 1890. p: 963.) Dr Thomson relates a case of Herpes in a girl aged 9, involving the area of skin supplied by the Internal Cutaneous Nerve of the right arm; there were also two groups of vesicles in the palm of the hand. The eruption was preceded for a day or two by severe pain in the affected region, probably neuritis, but there was no traumatic cause. The eruption appeared in crops which broke out successively in the upper arm, fore-arm and palm. Dr Thomson discussed the rarity of the condition, in respect of the distal distribution and the youthfulness of the patient; and also of the involvement of the Skin of the palm, usually supplied

by the Median Nerve, in a lesion dependent mainly or entirely on Neuritis of the Internal Cutaneous Nerve. This eruption is often seen after injuries to the nerves, and Charcot has given to it the name of "Zona traumatica". It usually appears about the fourth day or later after the injury, but Mr: Tomson reports a case (Med: Times & Gaz: Dec: 30. 1871) in which he saw it unusually early, namely the Second day.

(iii) Eczema, may occur and according to Weir Mitchell is a very constant feature with Glossy Skin.

(iii) Pemphigoid bullæ occur in crops on the Skin supplied by the injured nerve. They leave indelible scars. (Charcot.)

(iv). Erythema. A cutaneous redness resembling Erythema Pernio, in which there is limited action of the Skin and Subcutaneous Cellular Tissue simulating Phlegmon.

(v). Lichen and an Ichthyoid thickening of the Skin may, according to Professor Grainger Stewart, occur but I have not been able to find any cases of it.

(vi) Gangrene may supervene and the fingers drop off, or a slough may come away as in a case of Gangrene of the Ulnar side of the hand following an injury to the Ulnar Nerve, recorded by Root (N.Y. Med: Record. 1882. p: 560.)

(vii) Glossy Skin. This condition was first described by Mr (now Sir James) Paget (Med: Times & Gaz: March 26. 1864) The Skin has a peculiar, shining, glossy appearance. "The fingers are usually tapering, smooth, hairless, almost void of wrinkles, glossy, pink or ruddy or blotched as if with permanent chilblains." The

description given by Drs Morehouse, Keen and Weir Mitchell of this condition only differs from the preceding in that they add that "the Epithelium appeared to have been partially lost; so that the Cutis was exposed in places. (Loc: cit: p: 158.)
Many cases of this condition are recorded, not the least interesting being Professor Annandale's already referred to. This case, like nearly all the others, was accompanied with severe pain. Paget says it is "the accompaniment of certain intractable neuralgias", and W. Mitchell says (p: 156.) that it "is never present without burning pain." This, though true of the great majority of cases is not invariable for Mr: Bowlby (Loc: cit: p. 42.) gives two cases of Glossy Skin without any pain.
As to the duration of this condition Weir Mitchell says it varies from a few weeks to years, "but in all cases I have been able to follow, it has either been cured or gradually disappeared." That it may be of very long standing, is shewn by one of Mr: Bowlby's cases which was of more than 12 years standing and which showed no signs of improvement.
Some cases are recorded in which the condition comes and goes. It is probably due to an Atrophic condition of the Skin.

Sweat-Glands and their Secretion. In Glossy Skin there may be atrophy of these glands with diminution in the amount of secretion, as it may do also in some cases where there is no glossy condition of the Skin. In a number of Weir Mitchell's cases of Glossy Skin accompanied with Causalgia the Sweat was excessive in amount, very acid and with an intensely

disagreeable odour. Many of the cases in which the Secretion of sweat is excessive are apparently those in which there is only a partial division of the nerve with probably a resulting Neuritis.

Hair on the Skin may be altered; it may be split, short and coarse or absent altogether from atrophy of the roots as in Glossy skin.
Poulteau relates a case, quoted by Mougeot (vide infra) of traumatic neuralgia in which the hair was large, hard and with a great tendency to stand erect. This condition has also been seen in hair growing from hyperesthetic skin, and Weir Mitchell refers to a case in which a lancet wound was followed by remarkable symptoms, probably due to Neuritis affecting an hysterical temperament; the arm became thickly covered with hair. Section of the nerve gave partial relief and finally a cure was obtained after an attack of Pneumonia in which the patient was salivated.
Loss of hair after nerve sections is occasionally met with in animals, especially rabbits, and is sometimes renewed without re-union of the nerve having taken place.

The Nails may crack and curve or become smooth, shiny and vitreous, as in cases recorded by J. Hutchinson (Loc: cit:) and Mr: Bowlby. Weir Mitchell records a case in which the Median Nerve was injured and the nails became quite black from Blood effused under them, and their growth, although not entirely arrested, was for a time, retarded.
They may become friable and broken, sometimes thickened,

crumpled and furrowed.
The whole subject has been very fully and ably worked out by M. Mougeot in his very interest thesis, entitled "Recherches sur quelques troubles de nutrition consecutives aux affections des nerfs." Paris 1867.

Locomotory System.

Joints. The symptoms here may be very like those of Subacute Articular Rheumatism. The cartilage may erode, the ligaments ossify and the heads of the bones atrophy. There may be irregular bony growths in the neighbourhood of the joints. In the arm ~~changes~~ these changes occur chiefly in the Elbow, but the fingers have been known to suffer. In Annandale's case all the joints of the arm were stiff and painful. The condition usually terminates in Anchylosis, of a most intractable kind. The nature of the injury seems to have little to do with the production of these affections, as they have been known to follow on dislocations, ball wounds, contusion and even compression of a nerve.

Bones often suffer from Periostitis followed by Necrosis, with atrophy at their ends as mentioned above. They may become brittle and fracture spontaneously. Union is attended with the formation of a large amount of Callous. Sometimes there is ossification in the adjacent tissues.

Muscles may quickly atrophy, as in Maury and Duhring's case (supra), the Deltoid atrophied rapidly and to such an

extent; that the Humerus fell one inch from the Glenoid cavity. This case, I may mention, contained most of the symptoms about which I have been writing. Dryness and desquamation of the Skin; marked incurvation of the nails; Skin of the hands, especially about the knuckles red and smooth with desquamation of the Epidermis. There was also marked general oedema of the limb which is so common in all nerve injuries.

The muscular atrophy may to some slight extent be due to the paralysis, but nerve irritation alone is capable of determining rapid and early atrophy of the muscles, preceded by decrease or disappearance of Faradic contractility. Complete nerve division does not induce atrophy and loss of Electrical reaction until after an incomparably greater lapse of time, as in cases of prolonged inaction.

Muscular and cutaneous sensibility are often preserved nearly normal in cases of lesions of mixed nerves, even when rapid enfeblement of the Electrical contractility and consecutive muscular atrophy are carried very far. After a traumatic lesion in the course of a nerve the power of motion sometimes remains and only becomes enfeebled when trophic lesions have supervened in the muscle.

With regard to the Electrical reactions of an affected muscle Faradisation shows at once a diminution and then in intense cases total abolition of contractility. With the Galvanic current there is at first but a very slight enfeblement; but after the 3rd week it is followed by exaltation which persists during the whole period of Faradic depression and which disappears in its turn when Faradisa-

tion resumes its power. According to Duchenne (Loc: cit:) the Electrical Contractility of muscles may be diminished from the fifth day in cases of Compression, Contusion and Concussion of a mixed nerve.
Histologically, the muscular atrophy in such cases, partakes more of the nature of an Inflammatory process, than of a passive form. There is Hyperplasia of the Interstitial Connective Tissue and multiplication of the nuclei of the Sarcolemma; the fibres preserve their striated appearance, but decrease in their transverse diameter (Erb. Deutsch: Archiv: Bd: I. 1866. p: 44.)
This muscular atrophy may be accompanied by acute pains or abnormal sensations, and is very frequently followed by contraction. As to the cause of this contraction I cannot do better than quote Mr: Bowlby's words, (Loc: cit: p: 73.); he says it is probably due to the fact that "the muscle shrinks only so long as it is unopposed; if, therefore, its origin and insertion be unduly approximated during the process of Atrophy, they will remain in such a condition when the trophic changes have ceased, not because they have been drawn together by such changes, but that the atrophy found them in a certain position and fixed them there. For instance, after Section of the Median Nerve in the upper arm, it is very common for permanent flexion of the digits to ensue, but the reverse is not the case after division of the Musculo-Spiral, the fingers and wrist are not then extended, but, on the contrary, are flexed." The explanation is, "when the hand is paralysed, or when it is simply not in use, the

fingers naturally lie in a position of flexion and in this position they are gradually fixed by the Trophic changes".

Speaking, of these symptoms now in general, we find that they are almost always preceded or accompanied by burning pains. Anaesthesia is, as a rule, absent. They may any of them occur in cases of Punctures, Contusions, or Incomplete Section of the nerve, but are never found in Complete Section, but only in those conditions producing Neuritis. That they are all probably due to Inflammatory changes in the nerve, is strengthened by the fact that all these Symptoms occur in Leprosy, due, according to Virchow to a Leprous Perineuritis, with at first hyperaesthesia and afterwards anaesthesia. In this disease the limbs may drop off painlessly due to the Necrosis of the bones occurring in the later anaesthetic stages.
In diagnosing these symptoms, it behoves us to be careful how much we attribute to the nerve lesion itself. For example, in one of Sir James Paget's cases (Loc: cit:) though there was some sensation, the Temperature Sense was entirely gone; 2 ulcers were present on the fore-finger and thumb, but were found to have been caused by being held too near the fire. To a careless observer, such ulcers might have been taken for one of those resulting from a Subcutaneous Whitlow to which Mr: Jonathan Hutchinson has drawn attention in his report on such cases occurring in the London Hospital (Loc: cit:) and might erroneously have been considered as due to the actual Nerve lesion itself.

There are just two more points to which I wish to draw attention before I bring this subject to a close; the first of these is the Temperature of the part supplied by the injured nerve.

Soon after Section or Compression of a Nerve trunk the Temperature of the part supplied by that nerve, rises; this is due probably to Vaso-motor influence, as it has been shown not to occur if a tourniquet be previously placed over the Brachial Artery. Some weeks after complete division of a nerve the Temperature of the affected part is considerably lowered, possibly due to the Slowness of the Circulation and of the Trophic functions; this lowering in Weir Mitchells cases varied from 2° to 15° Fah: in Mr: Jonathan Hutchinsons cases from 6° to 10° Fah.

When a nerve is not divided but merely injured the lowering of the temperature varies from about ½° to 3° F: but if there be any irritative lesion, the temperature of the part may be normal or more generally raised. In cases of Glossy skin, while the affected part may be raised 2° or 3° Fah:, the Skin just above the burning part may be a degree or two below that of the healthy limb. "This slight loss of temperature above the wound is not uncommon in any nerve lesion, and may be due in part to the long and constant disuse of the limb." (W. Mitchell.)

The last Symptom to which I shall refer are the Eye Symptoms. Sir James Paget has drawn attention

to these in cases of injury to the Brachial Plexus. He says that the Pupil on the paralysed side is always smaller than the other; both re-act to light: There is no defect in the Sight. Dr Hughlings Jackson suggests that it is due to the relations of the Brachial Plexus with the Cilio-Spinal portion of the Spinal Cord.
Mdlle: A: Klumpke has written a very interesting paper on this subject. (Revue de Médicine. 1885: T V. p: 591.) in which she has collected a number of cases of injuries to the Brachial Plexus in which there are Eye symptoms. The other Symptoms here described are Myosis, narrowing or straightening (Fr: rétrécissement) of the Palpebral slit, retraction of the Globe, and in some cases flattening of the Cheek.
Section of the nerves of the Brachial Plexus is only accompanied by Oculo-pupillary phenomena when the Communicating branch from the 1st Dorsal Nerve is involved; they always exist alone and are never accompanied with any raso-motor disturbance of the face. "This shows the presence of irido-dilator fibres in the 1st Dorsal Nerve, as the raso-motor nerves for the face are connected with the 3rd, 4th, 5th and 6th Dorsal Nerves." (Klumpke. Loc: cit: p: 789.)
The whole subject of the existence of irido-dilator fibres etc: has been most ably worked out in a recent, and to use a German-expression, epoch-making paper by Dr Gaskell in the Proceedings of the Royal Society of London.

Such then are the more important considerations in connection with the Morphological and Pathological relations of the Nervous supply of the Upper Extremity. In a subject so wide, it is exceedingly difficult to prevent oneself from being irresistibly drawn in the Consideration of many and very interesting side issues.
I have tried as much as possible to curtail my remarks and to weed out all irrelevant matter, to bring the Thesis within reasonable limits. That it is still open to much improvement in this direction, I am fully aware, but Time does not permit of any more revision, so I must leave it, with all its many imperfections, in the knowledge that it is "something attempted, something done."

H. W. Marett Tims

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