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Physiology. — "*Experimental researches on the segmental innervation of the skin in dogs.*" By Prof. C. WINKLER from researches made in collaboration with Prof. G. A. VAN RIJNBERK. (VIIth Communication).

(Communicated in the meeting of September 24, 1910).

On the manner in which the dermatomata of the posterior extremity are ranged, and on their variability.

In our VIth communication we gave an elaborate description of form and situation of the skin-areas of the seven lumbar and the three sacral posterior nerve-roots. These researches led to the following results:

1. The 6 inferior lumbar roots and the 3 sacral posterior roots contribute to the innervation of the skin of the posterior extremity.
2. The skin-fields of LVI and of LVII have always lost all connection with the mid-dorsal and the mid-ventral lines of the trunk,

that of *Lv* has lost this connection in most cases. These areas cover the apex of the extremity, this latter being considered as a cone. They were therefore called *apical* or *top-dermatomata*.

3. All other skin-fields on the contrary retain a connection both with the mid-dorsal and the mid-ventral line. They are situated on the basal margin of the cone, to which the extremity was compared and were therefore called *marginal* dermatomata. The skin-fields situated cranially from the top-dermatomata — *Liv*, *Liii* and *Lii* — we called *cranial marginal dermatomata*, as opposed to those situated caudally from them, which were designated as *caudal marginal dermatomata*.

4. The skinfield of *Lv* (and in some cases even that of *Liv*) must be ranged between the marginal and the apical dermatomata, generally it behaves like an apical dermatoma, occasionally however it retains a connection with the mid-ventral line of the trunk, and whenever such is the case, it presents in this respect the characteristics of a marginal dermatoma.

What now remains to be elucidated is the reciprocal relation between these areas.

The three *cranial* marginal dermatomata cover together a smaller zone of the skin on the *dorso-lateral* surface of trunk and extremity than on the *medio-ventral* surface. With the *caudal* marginal dermatomata exactly the opposite is the case. At the same time however the *caudal* marginal dermatomata cover a *larger* field on the *dorso-lateral* surface of trunk and extremity than that covered by the *cranial* marginal dermatomata. On the ventro-medial surface these conditions are reversed.

If *Lvii*, *Lvi*, and *Lv* are cut through, the sensibility of the apical dermatomata being consequently destroyed, sensibility is retained along the mid dorsal and mid-ventral lines of the trunk.

The sensible zone along the mid-dorsal line of the trunk extends far on the dorso-lateral surface of the extremity, nearly unto the epicondylus lateralis femoris. The remaining sensible zone along the mid-ventral line is far less extended on the ventro-medial surface of the extremity, it continues only unto a few centimeters laterally from the symphysis pubis.

After carefully comparing the *caudal boundaries* of the *cranial* marginal dermatomata with the *cranial boundaries* of the *caudal* marginal dermatomata we find at the mid-dorsal line of the trunk the following conditions:

The caudal boundary of the skin-field of *Lii* goes from the Vth vertebra along the upper margin of the crista ilei; the cranial boun-

dary of the skinfield of *S_{III}* goes from the inferior margin of the sacrum between tuber ischii and anus towards the perineum. These boundaries therefore do not touch one another anywhere.

The caudal boundary of the skinfield of *L_{III}* originates near the sacrum, and passes between crista ilei and trochanter just above this latter in the direction of the epicondylus lateralis femoris; the cranial boundary of the field of *S_{II}* originates on the sacrum and goes from thence towards the tuber ischii. Between sacrum and trochanter these two boundaries run together for some extent.

The caudal boundary of the skinfield of *L_{IV}* originates at the sacrum and goes towards the capitulum fibulae, either just above or just below the trochanter; the cranial boundary of *S_I* has likewise its origin on the sacrum, and goes either just above or just below the trochanter in the direction of the epicondylus lateralis femoris, diverging to the popliteal space.

In this manner the joint caudal boundaries of the cranial marginal dermatomata *L_{III}* and *L_{IV}* form a line from the sacrum to the epicondylus lateralis femoris passing over the trochanter, as is likewise done by the joint cranial boundaries of the caudal marginal dermatomata *S_{II}* and *S_I*.

The skin-fields of *L_{III}* and *L_{IV}*, of *S_{II}* and *S_I* only slightly overlap one another here, they only are bounded by one another, whilst *L_{II}* and *S_{III}* are absolutely unconnected together.

As far as it is bounded by marginal areas, the line leaving the mid-dorsal line of the trunk at the sacrum and passing over the trochanter in the direction of the epicondylus lateralis femoris, may be considered as SHERRINGTON'S mid-dorsal-line of the extremity or as BOLK'S dorsal boundary of differentiation.

At the mid-ventral line of the trunk the relation between the boundaries of the marginal areas is different. There, the caudal boundaries of the cranial areas *L_{II}*, *L_{III}* and *L_{IV}* all converge towards the short line, measuring only a few centimeters, which may be traced from the symphysis to a point situated in females alongside of the genital tuberosity or even cranially from it, in males alongside of the root of the prepuce.

The cranial boundaries of the caudal marginal areas *S_{III}*, *S_{II}*, and *S_I* likewise converge to this line.

At the mid-ventral line of the trunk, the line along which the cranial and caudal marginal areas are bounded by one another is accordingly very short. This short line going from the symphysis towards the point alongside of the genital tuberosity and cranial from it, may be considered as SHERRINGTON'S mid-ventral line of the

extremity or as BOLK's ventral boundary of differentiation, (as far as bounded by marginal dermatomata).

The dorsal axis-line of the extremity, or the dorsal boundary of differentiation, corresponding to marginal dermatomata is therefore much longer than the equivalent ventral axis-line.

The subsequent course of these axis-lines however can only be demonstrated, when some insight is obtained into the manner in which the apical dermatomata are ranged and when their reciprocal variability and that of the marginal dermatomata have been treated at some length.

In order to give an instance of the way in which the skin-fields are ranged on the posterior extremity, the same image may serve that we made use of already when treating of the anterior extremity. There we compared the ranging of the skin-fields with that of floral leaves covering a flowerbud. The marginal dermatomata, like the basal floral leaves, perform this covering by pairs.

In applying this comparison likewise to the posterior extremity it must be kept in mind however:

- a.* that the hindleg is larger and longer than the foreleg;
- b.* that the posterior extremity, growing in caudo-cranial direction, suffers a greater rotation than the anterior one, the most cranial toe (the solitary nail) becoming situated thereby far medialward.

The greater length of the extremity finds an expression in the fact that 9 posterior nerve-roots contribute to its innervation (against 8 for the fore-leg), and still more in this, that three apical dermatomata — *Lv*, *Lvi* and, *Lvii* — cover the nether-leg and the foot (against 2 covering the top of the fore-leg).

That this extremity suffers a greater rotation finds an expression in the fact that at the mid-ventral line of the trunk the cranial and caudal marginal dermatomata overlap one another so much with their ventral portions, that in this region the areas *Lii*, *Liii*, *Liv*, *Si*, *Sii*, and *Siii* overlap one another. Such is in no wise the case at the mid-dorsal line of the trunk, where the caudal margin of *Ln* in that region does not join the cranial margin of *Sm*.

Moreover the remarkable behaviour of the area *Liv*, is in accordance with this fact. It sometimes occurs that this skinfield does not join the mid-dorsal line of the trunk. In all cases however, where we observed this variation, it had to be ascribed to so-called formation of caricatures¹⁾, as it never persisted. Notwithstanding that, the

¹⁾ In former communications we described how skinfields, isolated under unfavourable auspices (profuse hemorrhagy, prolonged narcosis, shock etc.) suffer alterations in form, appearing in a regular way, but not persisting. We called this "formation of caricatures", and made it an object of research.

skin-field of *L_{IV}* behaved otherwise than the dermatomata of the trunk, where the first signs of a caricature was never found in the *dorsal*, but always in the *ventral* region. It is likewise in accordance with this line of thought, that the skinfield of *L_V* never presents a connexion with the mid-dorsal line, whilst it not rarely presents a connexion with the mid-ventral line. Apparently both skinfields are dislocated farther from the mid-dorsal than from the mid-ventral line.

Still other facts may also be considered as an expression of the intense rotation of the extremity, in which the skin takes part. Firstly the situation of the cranial marginal dermatomata, which occupy much more territory on the ventro-medial surface of the extremity than on its latero-dorsal surface; then the behaviour of the skinfield of *L_V* which, being fixed to the first cranial toe (solitary medial nail), has turned almost completely on the medial surface of the extremity and presents only a small top on the dorso-lateral surface; further the manner in which are situated (the topdermatoma *L_{VII}* and) the caudal marginal dermatomata, whose extension, contrary to that of the cranial areas, is much larger on the latero-dorsal surface of the extremity; and lastly the shape of the topdermatomata, among which *L_{VI}* occupies a middle position. They are wound spirally around the forepart of the extremity, in such a manner that the longitudinal axis of each of these skinfields is placed in latero-medial direction.

Taking all this into account, the following scheme may be designed for the ranging of the dermatomata on the posterior extremity. The areas of *L_{II}* and *S_{II}* represent the most basal floral leaves, leaves, joined together at the mid-ventral line of the trunk, but not rejoining one another at the mid-dorsal line.

The second pair of floral leaves is formed by the skin-fields of *L_{III}* and *S_{II}*, joined together both at the mid-ventral and at the mid-dorsal line, but covering a larger portion of the basis of the cone at the latter.

Still more clearly expressed are these relations in the third pair of floral leaves, the skin-fields of *L_{IV}* and *S_I*, which are still connected both at the mid-ventral and mid-dorsal lines, but whilst they encompass the dorso-lateral crural surface unto past the middle of it, this encompassment on the ventro-medial basis of the extremity, continues at the utmost to the medial fourth of the inguinal fold.

This deficiency of the marginal dermatomata in covering the ventro-medial surface of the extremity is filled up by the skin-field of *L_V*, which has been removed almost entirely to the ventral (medial) surface.

The apex (in casu the foot) is covered then by the skinfields of

*L*_{VI} and *L*_{VII}. The skinfield of *L*_{VI} is situated in the middle and for the covering of the foot it is supported on the medial side by that of *L*_V, on the latero-plantar side by that of *L*_{VII}.

These differences in the covering of the dorso-lateral and of the medio-ventral basis of the cone, the medial overlapping of the area of *L*_V and the spiral winding of the areas of *L*_V, *L*_{VI}, and *L*_{VII} are alike expressed by the image of a bud wrung sideways (see the scheme).

On such a bud it may easily be demonstrated, how the skinfields of the nerve-roots have maintained their segmental successive order, if a line is drawn through it, crossing one after another all radicular areas in their successive order.

This line begins at the origin of the inguinal fold, and continues in proximo-distal direction over the patella, between tuberositas tibiae and epicondylus femoris medialis, over the solitary nail to the medial second toe, crosses the foot along the dorso-plantar limit-line of the toes, and goes in disto-proximal direction between calcaneus and malleolus lateralis over the popliteal space to the tuber ischii. In following this line in the direction here indicated we find that it passes successively the tips of the different tongues, by which the areas of *L*_{II}, *L*_{III}, *L*_{IV}, and *L*_V are characterized, crossing transversally the top-dermatomata *L*_{VI} and *L*_{VII}, and returning over the tongues of the skinfields of *S*_I, *S*_{II}, en *S*_{III}. (Red line on the scheme). The skinfields are ranged along this line.

The skinfields, covering in this manner the extremity, though bound to fixed rules as regards their situation and the way in which they are ranged, are nevertheless within certain limits subject to important variations concerning their situation, extension, and shape.

The cranial marginal areas *L*_{II} and *L*_{III} still behave partly as trunk-dermatomata. In their variations they are dislocated more or less far in cranial or caudal direction, and are thus lying opposite a higher or a lower vertebra. As far as they partake in covering the extremity, their dislocation is combined with their linguiform prolongation being drawn in or protruded distalward.

The variations of the caudal marginal areas *S*_{II} and *S*_{III} are different. Their dorsal cranial boundaries are lying very near to one another, between sacrum and root of the coccyx, but the angle opening caudalward, described by these boundaries in leaving the mid-dorsal line is less acute for *S*_{II} ($\pm 45^\circ$) than for *S*_{III} ($\pm 30^\circ$). Their variations present no dislocation in caudal or cranial direction but the angle opening caudalward at their origin is reduced or enlarged, and at the same time the linguiform prolongation is displaced either a little or further

distalward. In this way it may occur that the tongue of the skinfield of *Si* advances on the surface of the nates between anus and tuber ischii, unto some centimeters past this latter.

The marginal dermatomata *Liv* and *Si*, which are already of far greater importance in covering the extremity, suffer hardly any dislocation, but follow in cranial or caudal direction lines which are called SHERRINGTON'S axial lines or BOLK'S boundaries of differentiation. On the other hand, in their variations, variability of length and the advancing distalward of the linguiform protrusion are an essential moment. The tongue of the skin-field of *Liv* may extend unto the tuberositas tibiae and in extreme cases it may even reach the medial surface of the foot. Still more forcibly this is expressed in the skin-field of *Si*, where the tongue sometimes extends to the popliteal space and in extreme cases, along the posterior surface of the under-leg, even to the lateral portion of the foot and the lateral toes.

The skinfield of *Iv* varies again in a different way, along the medial surface of the under-leg it sends out on the medial margin of the foot a tongue of variable length, now reaching not farther than the solitary nail (1st medial toe), then again extending unto the medial sole of the foot and the 2nd medial toe. So far this area behaves in the same manner as that of *Liv*.

But at the same time this skinfield, fixed at the medial surface of the foot, extends transversally over the knee and the underleg. In medial direction this may continue so far, that the mid-ventral line of the trunk is attained. In lateral direction it varies likewise. The dorso-proximal head of this skin-field may extend from the epicondylus lateralis unto far on the latero-dorsal crural surface, whilst its lateral boundary may reach the front margin of the underleg, sometimes crossing this and even extending unto the malleolus lateralis. Here therefore we observe two differently directed variations. The marginal areas advanced tongues along the direction of the line above described by us, they varied accordingly in the direction of this line, whilst the skin-field of *Lv* varies (likewise in the direction of this line) partly as *Liv*, partly perpendicularly on the direction in which succeeds the variation of the marginal areas. The variation perpendicular to the variation of the marginal areas is characteristic for the true top-dermatomata; corresponding to this fact the described line takes upon the paw a course rectangular to itself.

The skin-field of *Lvi* is situated laterally on the thigh, on the underleg on its front-surface, on the foot dorso-medially, and from thence it may encompass the plantar surface of the foot and all the toes. Accordingly this skinfield lies around the leg like a spiral

wound around it, and it is subject to the following variations:

1. the spiral area around the foot may be dislocated in toto, sometimes more medially, in other cases more laterally, and 2. there may be some territory added to it, either medially or laterally or on both sides, and this may go so far that the whole of the foot is encompassed by it.

The dorso-proximal head of this area is relatively fixed in place, though it may vary greatly in breadth. The ventro-proximal head suffers more important displacements, and it may even fail altogether. Accordingly the variations of this skin-field consist in a dislocation (especially on the foot) in the direction of the described line, which takes here a rectangular bend, i. e. rectangular to the direction of the variation of the marginal areas.

The skin-field of *Lvii* is situated dorsally on the thigh, dorso-laterally on the under-leg, ventro-laterally on the foot, it encompasses the dorsal side of the toes, and a larger or smaller portion of the soles of the toes and of the large plantar sole. Accordingly this skin-field, laterally from that of *Lvi* and parallel to it, is wound as a spiral zone around the under-leg and the foot.

Here again it is the distal part that varies most. The lateral surface of the foot indeed always belongs to *Lvu*, but the toes and the plantar surface are covered by this dermatoma farther or less in different cases. This skin-field varies likewise rectangularly to the direction of the variation of the marginal dermatomata.

Remarkable is the manner in which behave the proximal territories of the topdermatomata, which we called their heads. In this regard the topdermatomata differ between them, for the area of *Lv*, placed "à cheval" on the knee, has a large ventro-proximal head and a small dorso-proximal one, that of *Lvi* a large dorso-proximal one and a small ventro-proximal one, whilst in that of *Lvii* the ventro-proximal one is failing. The proximo-dorsal heads of *Lv* and *Lvi* overlap one another, that of *Lvii* approach nearer to the mid-dorsal line of the trunk, whilst of all three, the ventro-proximal head of *Lv*, if it does not quite reach the mid-ventral line of the trunk, approaches nearer to it than that of *Lvi*.

Accordingly it may be said, that the three top-dermatomata originate at the same point of a sufficiently well-defined region on the lateral surface of the thigh. Subsequently they extend next to one another, like the divisions of a fan, wound spirally round the under-leg and the foot, and in cases where there are variations, they swing to and fro in this region together.

We will now turn our attention again to the axial lines (SHERRINGTON)¹⁾ and the boundaries of differentiation (BOLK) on the posterior extremity.

As we observed, the origin of the three topdermatomata on the lateral thigh-surface is limited to a pretty well defined region, situated nearly at the point unto which the line was drawn, where the caudal boundaries of the cranial marginal areas reached dorsally the cranial boundaries of the caudal marginal areas.

It would not be justifiable to continue the dorsal axial line of the extremity farther than this point. Three successive areas *Lv*, *Lvi* and *Lvii*, overlapping one another in a large measure, extend from this place, like divisions of a fan.

The dorsal axial line therefore does not continue farther than the middle of the lateral thigh-surface.

On the medio-ventral surface of the extremity the case is different. We found here that the region where cranial marginal areas (*Lii*, *Liii*, and *Liv*) and the caudal ones (*Siii*, *Sii* and *Si*) rejoin one another, is a very short one. Here however it is possible to draw between the marginal dermatoma *Si* and the topdermatomata *Lv* and *Lvi*, a line answering to the definition given by SHERRINGTON for the axial line or by BOLK for the boundary of differentiation.

For our different isolations of the skinfields of *Lv* and *Lvi* all showed us medial boundaries, situated on the medial surface of the thigh and of the underleg nearly at the same place as is occupied there by the medial boundaries of *Si* and *Lvii*. Furthermore we have seen that in the important variations, characteristic for the skinfields of *Liv* and *Lv*, the medial margins of these are dislocated in different directions along that line. It is along this line that the skinfield of *Lv* reaches the mid-ventral line, and along it too that the skinfield of *Liv* extends a distal tongue on the medial surface of the under-leg. The same conditions prevail in the exceedingly great variations of *Si*. Whether the tongue of this skinfield extends to the popliteal space or to the toes, it is always this line that forms its medial boundary.

Accordingly, the ventral axial line must be drawn further from the middle of the genital tuberosity over the medial surface of thigh and under-leg unto the malleolus medialis.

¹⁾ SHERRINGTON's axial lines of the extremity are characterized by the very slight degree in which the areas bounded by it overlap one another. In this it reminds the "crossed overlapse", at the mid-dorsal and mid-ventral lines on the trunk, of the homonymous skin-fields of both halves of the body.

BOLK's boundary of differentiation is a boundary between dermatomata, which originally do not follow one another in the serial order, but are placed next to one another by the development of the extremity.

As the skin-fields vary in the direction of the line we have described, the variations of the marginal fields are found to move more or less in the direction of the longitudinal axis of the extremity. The topdermatomata swing to and fro rectangular to it, whilst L_v varies in both directions.

Still another circumstance must be added. As soon as a skinfield changes as to place and extension, its form changes likewise, and in such a manner that it shows an inclination to take the form of the field, whose place it usurps. This fact is illustrated by the fields of L_v and L_{vi} .

That of L_v varies in two directions. The tongue extends more or less far distalward along the medial border of the foot (from the solitary nail to the sole of the second medial toe), the heads are dislocated in dorso-ventral direction, and the ventro-proximal one may even reach the mid-ventral line. But that of L_{iv} too presents somewhat similar conditions. If the tongue, which in most cases does not pass the tuberositas tibiae, extends farther, it may go along the medial underleg unto the solitary nail. In such cases the skinfield of L_{iv} may be on the point of leaving the mid-dorsal line (formation of caricatures), and L_{iv} has then completely taken the form of L_v , just as L_v whenever it extends to the mid-ventral line, resembled L_{iv} in its form.

However great the variability of the single skin-fields may be, — still in their variations they are collectively bound to certain rules. In every individual there is a constant correlation between the topographical characteristics of all the skinfields situated on the extremity.

This correlation is expressed especially in the behaviour of the cranial and caudal marginal dermatomata and in some cases it can be demonstrated how a *reciprocal correlation* prevails in their variation. For an instance of this we refer to the isolation of the skinfield of S_i , which was found on dog 11¹⁾ extending a very long tongue unto the toes, whilst on dog 33¹⁾ the tongue was very short, only extending to the popliteal space. In both cases the caudal margin of L_{ii} is known. In the first case (tongue of S_i very long, protruded far cranialward), the caudal margin of L_{ii} is likewise shifted cranialward, passes above the crista ilei, and extends a tongue that goes unto 2 centimeters' distance from the patella. The further S_i advanced on the extremity, the farther L_{ii} drew back. These two skinfields, situated far from one another, show therefore a reciprocal correlation, or what may be called also a dislocation in the same direction, both cranialward or caudalward.

¹⁾ Cf. VIth Communication p. 304 and p. 303.

It may only be demonstrated in an indirect way, that the same holds good for top-dermatomata, situated next to one another. Still a comparison between several isolations sometimes tends to prove this. On dog 27 for instance the skinfield of *LVI* is isolated to the left and that of *LVII* to the right¹⁾, whilst the behaviour of the caudal boundaries of *LIII* to the left and *LIV* to the right indicate symmetrical relations between the two halves of the body. In this case the skinfield of *LVI* (to the left) leaves uncovered a large portion of the dorso-lateral border of the foot, it has accordingly been displaced somewhat cranialward, and that of *LVII* (to the right) fits completely in this gap and has accordingly been displaced in the same direction.

Without pretending to include all possible variations, we still have found a few fixed rules to which they are submitted.

1. The variations of the single skinfields take place in determined directions. The marginal dermatomata vary nearly in the direction of the longitudinal axis of the extremity (linguiform protrusion). The top-dermatomata vary in a direction rectangular to it. Both of them however along the "ranging line", above described by us.

2. Each single skinfield in an individual may occupy, wholly or partly, in several gradations, the place that is occupied in other individuals by the adjacent skinfield. Whenever a skinfield does this, it changes form at the same time and it bears the greater resemblance to this adjacent area, the more completely it usurps its place. We never met with a case, where a nerve-root undertook the innervation of the whole area, which in individual one or another got its innervation from the third nerve-root in cranial or caudal direction.

3. However great may be the separate variabilities, these variations ordinarily do not concern only one separate skinfield. Apparently in most cases they vary collectively, and then in such a manner that the whole series of them is displaced along the ranging line and the direction of the collective displacement is in most cases cranialward.

In 1856 TÜRCK²⁾ proved, that in dogs the posterior nerve-roots following on one another, supply the innervation of skin-fields,

¹⁾ Cf. *Ibidem* p. 295 and p. 301.

²⁾ L. TÜRCK, Vorläufige Ergebnisse von Experimentaluntersuchungen zur Ermittlung der Hautsensibilitätsbezirke der einzelnen Rückenmarksnervenpaare. Sitzber. der Math. Nat. Cl. der K. Ak. der Wiss. Wien 1856.

ranged in successive order, and that the serial ranging of the nerve-roots may be discovered also on the extremities. With the aid of the material collected by TÜRK in his researches, WEDL designed in 1869 schemata for the areas of innervation, also for those of the posterior extremity. Yet TÜRK had not given any special opinion about variability, and we are inclined to seek even in his silence hereupon the reason why these schemata came into existence. For if TÜRK could have rightly valued the variability, as it was made possible for us to value it by the experiences of later anatomists, the difficulty of compressing the varying configurations of the dermatomata within the bounds of a scheme, would have become still more evident to WEDL¹⁾ too, than he found it already.

Since then however FÜRBRINGER and HERRINGHAM have first put forth the principle, which was afterwards amply elaborated by the researches of LANGLEY, SHERRINGTON and BOLK, and which has led to the modern conception of the segmental variations as being serial variations.

The meaning of this is, that the composition of the peripheral nerve-plexus of the extremity, and of the innervation of muscles and skin of the extremity is dependent on the different segmental level on which the extremity was developed. It may be displaced cranialward or caudalward for a segment.

If the origin of the extremity has been displaced one segment cranialward, it gets the material for its innervation from a region of the medulla situated one segment more cranialward, and the innervation of the periphery corresponds to more cranial elements of root-fibres. In such cases a segment is added cranially, caudally a segment falls off, but the successive order of the innervation areas for skin and muscles is maintained (cf. LANGLEY²⁾, SHERRINGTON's³⁾)

¹⁾ WEDL, weiland Prof. L. TÜRK, Ueber die Hautsensibilitätsbezirke etc. Abhandlungen der Math. Nat. Cl. der K. Ak. der Wiss. zu Wien, 1869, writes in his preface to the publication of researches left by TÜRK: "Die Varianten der Sensibilitätsbezirke hat der Verfasser . . . auf die Schablone transponirt. Es ist hierbei allerdings der missliche Umstand eingetreten, dass einzelne Figuren an Klarheit eingebüsst, und es selbst mir trotz Zuhilfenahme der einzelnen Experimente nicht immer möglich war zu entscheiden, ob so manche Variante zu dem Bezirke des einen oder anderen Nerven gehöre.

²⁾ J. N. LANGLEY, On the course and connection of the secretory fibres supplying the sweat glands of the foot of the cat. Journal of Physiology. London 1891. Vol. XII. No. 4, p. 347.

³⁾ C. S. SHERRINGTON, An experimental investigation of the nerve-roots which enter into the formation of the sacro-lumbal plexus of *Macacus Rhesus*. Abstr. of the Proceedings of the Royal Soc. of London 1893, Vol. 53, p. 459, Vol. 54, p. 213.

prefixed type). *Mutatis mutandis* the same holds good for cases, where the extremity originates one segment more caudally (SHERRINGTON's postfixed type). Independently of SHERRINGTON, BOLK¹⁾ arrived at the same conclusion, when he represented the series of dermatomata on the extremity as the links of a chain, which may be drawn hither and thither round a fixed bar.

Our results again are for the greater part in accordance with the rules set down by SHERRINGTON and BOLK. A great many of the variations we found, fit perfectly in the frame of the serial displacement of the dermatomata.

The apparent contradiction between the direction of the variations of marginal and of apical dermatomata, the former nearly following the longitudinal axis of the extremity, the latter rectangular to it, means only a variation along the course of the "ranging line" described by us (see page 436), and accordingly fits in the frame of the serial displacement.

BOLK's image of the linked chain involves likewise, that the direction of the variations of the marginal dermatomata must be placed rectangular to that of the apical ones.

Less obvious appeared the fact, that with serial displacement the form of the skin-fields should change so completely. Still this was found to be the case, but the remarkable behaviour of *Si*, where the extension of the tongue may alternate from the popliteal space to the lateral border of the foot, or that of *Liv*, where this extension may alternate from the tub. tibiae to the malleolus medialis, fits nevertheless perfectly into the frame-work of a serial displacement.

If the more distal region of the origin of the extremity is represented by an exceedingly steep cone, then a very slight displacement of this steep cone (the nerves growing into it, being imagined as a series of parallel fascicles) may be the cause that the extremes of this series may penetrate either very little or very far distalward into the cone. When the displacement is caudalward, *Si* advances far distally on the caudal border of the cone, when it is cranialward, *Si* advances less far, but instead of it *Liv*, situated at the cranial border, goes farther. And as the basis of the cone is broad and short, this relation becomes less evident than it is for *Liv* and *Si*, for *Lii*, *Liii*, *Sii* and *Sir*, which supply the innervation of the broad and low superior part of the conic circumference.

Finally the behaviour of the cranial and caudal marginal dermatomata, showing a reciprocal correlation (as described by us

¹⁾ L. Bolk, Een en ander uit de segmentaal-anatomic van het menschelijk lichaam, Weekbl. van het N. T. v. Geneesk. 1897, Deel I 24, p. 982, Deel II, p. 366.

for *LIII* and *Si*, *LVI* and *LVII*) tends likewise to prove a serial variation, dependent on the different segmental level of the origin of the extremity.

Most important of all in demonstrating this is perhaps the tendency of the skin-fields to take also one another's form whenever they happen to have taken one another's place.

We have described this for *LIV* and *Lv*. The skinfield of *LIV* may show an almost perfect or even perfect likeness to that of *Lv* and the reverse.

But in cases where *LIV* took the place, and together with it the form of *Lv*, still other characteristic alterations were found in the segmental relations of other organs (vertebral column and plexus).

Whenever *LIV* sends its long tongue medialward (we found this in three cases), we always found only 12 thoracic vertebrae with their costae. The 13th without costa then appears as 1st lumbar vertebra and the seventh lumbar vertebra has been absorbed entirely or partly in the sacrum. Accordingly the vertebral column presented a reason for assuming that it had been shortened by one vertebra, a fact corresponding to a cranial displacement of the origin of the extremity¹).

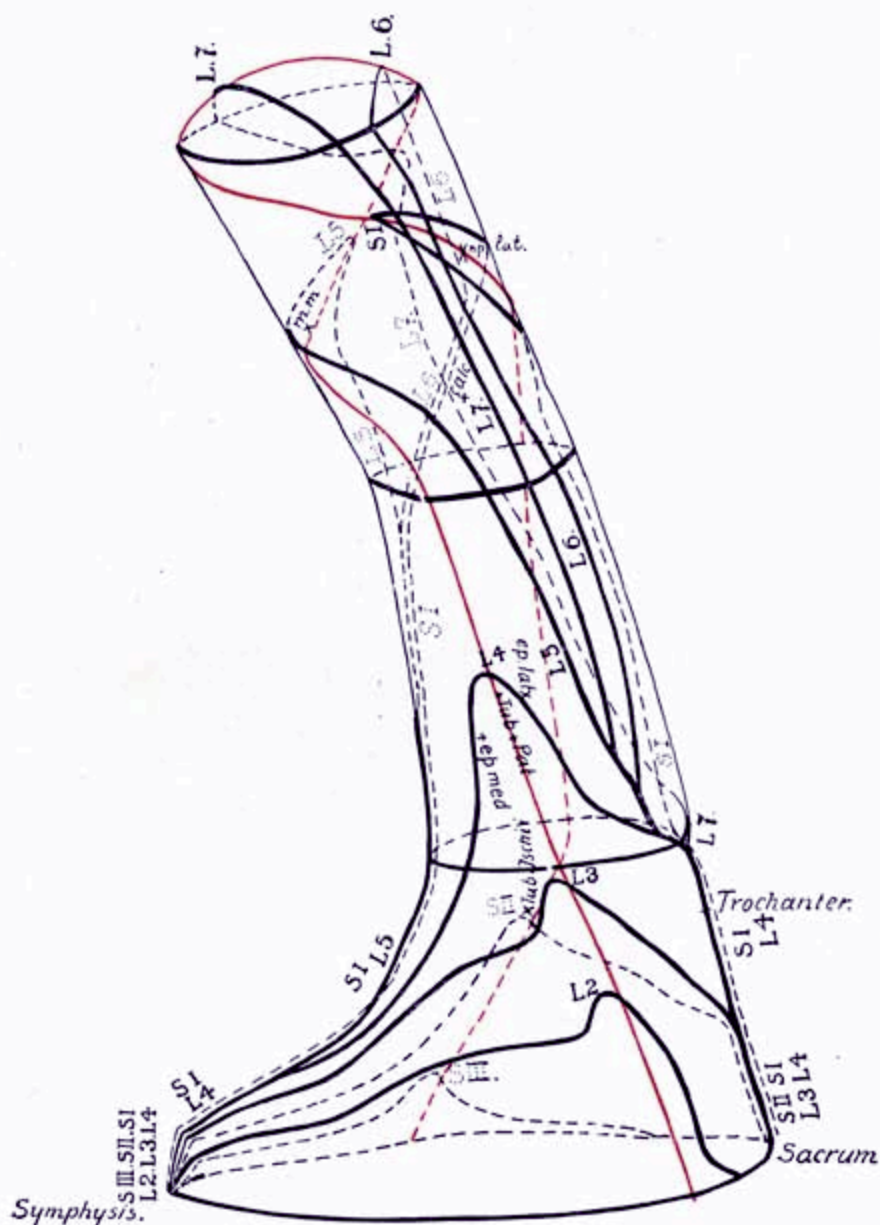
Dr. FRÉTS, who has made researches on the sacro-lumbar plexus of our and other cases, obtained accordant results. They will be published by him separately.

But the here mentioned observations, that apparently it is decided by the periphery what form the skin-field will assume; that it seems to be quite indifferent for its form, whether the material for its innervation has been supplied by a more cranial or a more caudal level of the medulla; that an identical form of the skinfield may be realized, independent of its innervation being derived either from *LIV* or from *Lv*, if only the periphery presents an attitude favourable to such a form, — seem to us of the greatest importance.

Though a great many of the above described instances are in accordance with the theory of the serial displacement, still there

¹) We are inclined to think that the expression in a scheme of these dermatomata by WEDL and TÜRKCK was based upon their reckoning without these variations. There is sufficient reason for this. If TÜRKCK thought to cut through on a prefixed type with e. g. six true lumbar vertebrae (the 7th being absorbed in the sacrum) the 5th lumbar nerve-root, it is evident that he cut through in reality the 4th, but found none the less a skinfield, corresponding to that of *Lv* in not prefixed individuals. TÜRKCK did not value rightly the extremes of the variations, because in such cases the 13th thoracic vertebra frequently bears no costa. In such cases however, the root that seems to be *Lvii* is *Lvi* etc

C. WINKLER and G. A. VAN RIJNBEEK. "Experimental researches on the segmental innervation of the skin in dogs."
(VIIth communication).



Scheme of the skin-areas of the posterior extremity which is represented as a cone. The red line is the ranging-line described in our paper. This line runs between patella (+ pat), tuberositas tibiae (+ tub) and epicondylus medialis femoris (+ ep. med), towards the back-side of the malleolus medialis (+ m m.). It crosses the toes, returns on the fore-side of the foot and passing the malleolus lateralis (+ m. lat) it regains the fossa poplitea and goes to the tuber ischii (+ tub, ischii).

remains a certain number of cases, that will not fit into this theory. We will indicate two groups of them.

It may happen, that *Liv* advances very far on the extremity, assuming the place and likewise the form of *Lv*, a cranial displacement of the cranial margin of the extremity being thereby apparently indicated (and affirmed moreover by the vertebral column), whilst yet there is no reciprocal correlation with the caudal marginal dermatomata, and the skin-field of *Cocci* is partly situated before the anus. This indicates a caudal displacement of the caudal margin of the extremity whose cranial margin was displaced cranialward. In other words, in these cases the origin of the extremity appears to be not displaced but enlarged.

We found also, in examining the different medullae operated upon, that the dorsal nerve-roots may vary very much in thickness.

For instance the relative thickness of *Lvii* compared with *Si* is subject to much variation. *Lvii* indeed is always thicker than *Si*, sometimes however they are almost equal in thickness, whilst in other cases *Si* appears only as a thin thread compared with *Lvii*. Frequently the two nerve-roots have a common course, and it even happens that their intervertebral ganglia are partly grown together.

A similar, but never so strongly expressed reciprocal relation exists between *Liv* and *Lv*. *Liv* too is always thinner than *Lv*. *Lvi* is the thickest of the lumbar nerve-roots. We did not always find, however, that a large skin-field corresponded to a thick isolated nerve-root or vice versa. We found indeed *Si* sometimes exceedingly thin, *Lvii* exceedingly thick, and at the same time *Liv* very thick compared with *Lv*,, a relation which, (if a larger skinfield corresponds to a thicker nerve-root) indicates a reciprocal correlation and consequently a serial displacement.

But we did observe still very different relations in the thickness of single nerve-roots, relations we will not insist upon at present.

Whether besides the variations that may be considered as based upon serial displacement (and that may be then observed in numerous gradations, even extending to one segment), other variations may occur, dependent on enlarged origin of the extremity or based on mutual interchange of root-fibres, or lastly based on the possibility of more or less oblique out-growth of the origin of the extremity, — a possibility we did not treat of in this paper — these are questions for the elucidation of which the material we dispose of at present, is not sufficient. It is our purpose to resume them later on.