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**Physiology.** — “*Form and function of the trunkdermatome tested by the strychnine-segmentzones*”<sup>1)</sup>. By J. J. H. M. KLESSENS. Communicated by Prof. WINKLER.

(Communicated in the meeting of October 26, 1912).

The theoretical trunkdermatome of man and mammals is a trapezium, the short basis of which lies in the dorsal diameter, and the long basis of which lies in the ventral diameter. This statement dates already from TURCK, who called the attention to the fact that dorsally a same number of posterior roots provides for the skin covering the thoracal-vertebrae, whilst ventrally they do so for a much larger part of the skin, extending from the manubrium sterni to the symphysis pubica.

It seems that the anatomically prepared dermatomes (BOLK<sup>2)</sup>, GROSSER and FRÖHLICH<sup>3)</sup>) support this view.

The root-fields experimentally fixed according to the “remaining aesthesia” method, that SHERRINGTON<sup>4)</sup> found with *Macacus rhesus*, have likewise a form answering to the theoretically postulated one. SHERRINGTON writes, that the string formed by the dermatomes on the trunk is, “somewhat wider near its ventral than at its dorsal end”. And passim: “each zone is narrowest at its dorsal end”. Yet SHERRINGTON remarks that the periphery of the dermatomes feels stronger than the central part, so that going from the border towards the centre for the fixation of sensibility, occasionally the sensibility suddenly appears to become much sharper.

A similar fact was stated for the dog by C. WINKLER and VAN RIJNBERK<sup>5)</sup>. They saw namely that the sensible isolated zone generally deviated in extent and form from the theoretical dermatome. These

<sup>1)</sup> According to investigations made in the physiological laboratory of the University of Amsterdam.

<sup>2)</sup> L. BOLK, Die Segmentdifferenzirung des menschlichen Rumpfes und seiner Extremitäten. I—IV. Morphologisch Jahrbuch Bd. XXV. XXVI. XXVII. XXVIII. Leipzig 1897—1900 and: 1. BOLK. Een en ander uit de segmentaal anatomie van het menschelijk lichaam. Ned. Tijds. v. Geneeskunde. Amsterdam. 1897. Vol. I. p. 982. Vol. II. p. 366.

<sup>3)</sup> O. GROSSER und A. FRÖHLICH. Beitr. z. Kenntniss der Dermatome der menschlichen Rumpfhaut. Morphol. Jahrb. XXX. S. 308. Leipzig 1902.

<sup>4)</sup> C. S. SHERRINGTON. Examination of the peripheral Distribution of the fibers of the posterior Roots of some spinal nerves I Transactions of the Royal Society of London. B. Vol. 184. p. 691. London. 1892.

<sup>5)</sup> C. WINKLER and G. VAN RIJNBERK. On function and structure of the trunkdermatoma I—IV. Proc. of the K. Akademie van Wetenschappen te Amsterdam. 1902—1905. Amsterdam, and: C. WINKLER. Ueber die Rumpfermatome. Ein experimenteller Beitrag z. Lehre der Segmental-Innervation der Haut. Monatschr. f. Psychiatrie und Neurologie. Bd. XIII. S. 161. Berlin. 1903.

deviations were greater in proportion as the operative trauma for the investigation had been larger. Moreover they found a permanent regularity in the way in which the deviations presented themselves.

These facts brought them to the view that the isolated root-field that could experimentally be ascertained, can never have the entire extent of the theoretical dermatome. They supposed therefore that even in the most favourable experiments beyond the limits of the sensible zone, always another little strip of skin must be admitted as belonging to the dermatome. This strip they called "Marginal area", and pronounced i.a. the hypothesis which for the rest was no further elaborated, that this strip is not capable of independent sensation (i.e. without the assistance of the overlapping). This isolated sensible zone they called "central area". In the experiments of W. and v. R. the form and extent of this zone appeared to be extremely variable and dependent on the postoperative conditions of the isolated root and of the spinal cord. With a large operative trauma the form of the central area was no more than a "caricature" and its extent much smaller than might be expected from the dermatome. W. and v. R. call this part of the dermatome, that was found to be insensible likewise "marginal area". If we summarize W. and v. R.'s views, we find that even in the most favourable experimental isolations the zone that is found to be sensible does not constitute the whole theoretical dermatome, but only a central area of it shut in between two marginal zones that cannot be indicated. In unfavourable cases, when the central area becomes a caricature, the marginal area is widened at the expense of the central area.

In W. and v. R.'s experiments the latter phenomenon always occurred first and strongest in the ventral zone of the dermatome. As an explanation of the fact that the sensibility in the ventral zone appears to be feebler W. and v. R. adduce two hypotheses: 1<sup>st</sup> that the ventral part is the most excentric part of the dermatome (i.e. most distant from the C.Z.S. spinal cord and spinalganglion)<sup>1)</sup> and 2<sup>nd</sup> that on account of the "stretching" of the skin between manubrium sterni and symphysis the extremities of the nerves had to extend over a larger surface than in the dorsal zone.

On the occasion of a systematic examination of the strychnine-

1) Compare likewise: G. VAN RIJNBERK. On the fact of sensible skin dying away in a centripetal direction Proc. of the K. Akademie v. Wetenschappen te Amsterdam 1903, and G. VAN RIJNBERK. Beobachtungen über die Pigmentation der Haut bei Scyllium catulus und canicula und deren Zuordnung zu der segmentalen Hautinnervation dieser Thiere. PÉTRUS CAMPER. Nederl. Bijdragen tot de Anatomie. Dl. III. p. 137. Haarlem. 1904.

segmentzones of cats<sup>1)</sup>, of which I hope to make detailed communications on some subsequent occasion, I found some facts which, in connection with the questions mentioned above, I suppose to be of sufficient importance to be separately communicated here. My experiments are made on cats that by a high transverse section had been converted into spinal-cord animals. I apply then strychnine in the place where a root enters, and cut besides craniocally two roots. Consequently I make use of a combination of the remaining aesthesia method and that of the local strychnine-poisoning of the spinal cord. I do so to be sure, that though there may perhaps exist some doubt about the decidedly local application of the poison, at all events, no stimuli of the skin can reach the spinal cord from roots situated beside those, of which I intend to fix the skin-zone.

By a slight touch of the skin with a pencil we look then further for hyperreflexion<sup>2)</sup>: usually this can already be shown a few minutes after the poisoning.

A peculiar fact that I have regularly stated at the determination and fixation of the zones, is that hyperreflexion appears first and strongest in a definite string-shaped zone, which however soon widens because cranially and caudally a strip of skin which at first was not hyperreflexory, becomes so now, though in an inferior degree to the zones that could first be indicated. When the entire strychnine-segmentzone has reached its largest extent, this difference of intensity still continues to exist, so that we can distinguish a central zone with stronger hyperreflexion from a narrower peripheric strip with less strong hyperreflexion.

This strychnine-segmentzone can consequently be divided into a strong hyperreflexory inner-zone which can soon be indicated, shut in by two feebler outer-zones appearing a little later.

These facts show an unmistakable correspondence with those mentioned above communicated partly by SHERRINGTON, partly by W. and v. R. I shall try to elucidate this peculiar behaviour of strychnine-segmentzones in connection with what has been found by the above-mentioned authors, chiefly on account of indications ascertained with a cat (marked 32) where, under specially favourable circumstances, successively three strychnine-segmentzones could be fixed, namely to the left Th. VIII and Th. XI to the right Th. VII.

1) Compare J. G. DUSSEY DE BARENNE. Die Strychninwirkung auf das Zentralnervensystem. I—IV. Folia Neurobiologica. Bl. IV. V. VI. Haarlem. 1910—1912.

2) With this form of strychnineapplication no Tetanus takes place, but only hyperreflexion.

1. *Strychnine-segmentzone Th. VIII left.*

After the cat had been made a spinal-cord-animal by a transverse section at Thor. II a piece of thoracal spinal cord is laid bare in the usual way, and the place of introduction left of Th. VIII moistened with strychnine. Moreover the dorsal roots of Th. VI, VII, IX and X are cut intradurally. Soon it is possible to ascertain a strongly hyperreflectory zone of the skin, which gradually widens and a few minutes after the poisoning reaches its maximal extent. It is then still very easy to distinguish an inner-zone and two outer-zones.

a. *Description of the inner-zone.*

The central-zone is almost string-shaped. The cranial and caudal limits first run parallel to each other, perpendicular to the axis of the body. On the centre of the lateral surface the cranial limit makes however a curve convex to cranial. A similar phenomenon is scarcely indicated in the caudal limit.<sup>1)</sup>

The bordering lines continue to run parallel and perpendicular as far as the ventral surface. Here they converge slightly, so that the central zone - that was at the d. d. 30 mm. wide, measures in the v. d. only 23 mm. The central zone however goes beyond the v. d. and finishes, sharply limited, about 4 mm. overlapping the crossed side. Here the hyperreflexion is somewhat slighter than in the rest of the zone. (A dorsal crossed overlap could not be fixed on account of the median skin-section).

The zone hitherto described is surrounded by a ventrally strongly widening outer-zone which being itself less reflectory than the inner-zone, contrasted however strongly with the adjoining areflectory resp. normally reflectory zone. The outer-limits of the outer-zone are of course at the same time the boundary of the total strychnine-segment-zone, which I am going to describe now.

b. *Description of the total strychnine-segmentzone (outer-limits of the outer-zone).*

Scarcely to be recognized at the d. d., running closely along the

<sup>1)</sup> A similar fact is often indicated by W. and R. Compare e.g. their fig. 27 of their IIIrd communication. Here the 13th and 16th spinal roots were isolated. The caudal zone of the ventral part seems to be considerably shrunk, whilst cranially the lateral outward curve of the central area breaks through the anaesthetic zone. To explain these phenomena they admitted a widening of the central area in the lateral part, whilst at the same time it is supposed that here a relative minimum of sensibility is found. As now a similar removal of the border existed cranially and not caudally likewise with my cat, this fact may perhaps also be regarded as a peculiarity of the 16th root-field.

foremost limit of the inner-zone, the cranial limit of the total zone soon assumes a course directed more towards cranial, so that the cranial outer-zone, in the d. d. scarcely a few mm. wide, is in the v. d. 10 mm. wide.

The caudal boundary-line continues to run at the d. d. almost together with the caudal limit of the inner-zone; it is here hardly a few mm. to the outside. Its further course however is like that of the cranial limit strongly divergent, consequently here in a strong caudal direction, so that, especially in the ventral zone, a wide outer-zone appears, which in the v. d. is 21 mm. wide. The caudal outer-zone is consequently almost twice as wide as the cranial one.

If we regard now this large extent, and the shape that the total strychnine-segmentzone obtains by the addition of the so wide outer-zones, we should be inclined to admit that almost the whole theoretical, ideal dermatome has appeared here. If now we remember W. and v. R.'s conclusion:

“Isoliert man experimentell ein Dermatome so entspricht der erhaltene sensible Bezirk nie weder der Ausdehnung, noch der Gestalt nach, dem theoretischen oder anatomischen Dermatome,”<sup>1)</sup> then the combined strychnine-isolation method applied by me affords doubtless better results than the simple “remaining aesthesia method”. For under the influence of the strychnine poisoning the limited value for the reflexion diminishes so much that there can hardly anymore be question of a marginal area in the sense of W. and v. R.

## 2. *Strychnine-segment zone of Th. XI left.*

After the rootfield of Th. VIII had in this way been fixed and measured, the root Th. XI was isolated in the same way by cutting the dorsal roots of Th. XII and XIII, and locally poisoned with strychnine.

The hyperaesthetical zone that appeared here likewise, had a steep trapezium shape, and was when the total extent had been reached, at the d. d. 34 mm., at the v. d. 49 mm. wide. Here the cranial limit could however only be fixed, after the Th. VII, isolated in the preceding experiment, had been cut. For it appeared that the cranial limit of Th. XI crossed the caudal limit of Th. VIII in the level of its lateral cranial curve.

### a. *Description of the central zone.*

The central zone of Th. XI occupies dorsally also again almost

<sup>1)</sup> G. VAN RIJNBEEK. Versuch einer Segmental-Anatomie. Ergebnisse der Anatomie. Bd. XVIII. Wiesbaden 1910, S. 544.

the total extent of the strychnine-segmentzone. Its limits have here likewise a parallel and perpendicular direction. On the lateral and ventral surface they assume also a distinctly converging course so that when they reach the ventral diameter, they are only 16 mm. distant from each other, whilst at the dorsal diameter the inner-zone is about 32 mm. wide.

b. *Description of the outer-limits of the outer-zone. (Total strychnine-segmentzone).*

The cranial limit lies in the dorsal zone, scarcely perceptibly cranially from the cranial limit of the inner-zone. On the lateral surface however when the cranial limit of the inner-zone begins to converge, (consequently begins to move in a caudal direction), it deviates strongly diverging (consequently in a cranial direction). The outer-zone hereby becomes rather wide; at the v. d. it attains a width of 21 mm. The caudal limit of the outer-zone follows that of the inner-zone as far as the lateral surface, then about the place where likewise the cranial limits of outer- and inner-zone deviate from each other, it takes also a diverging direction (consequently follows a caudal course). In the level of the axil-groin-fold line the outer-zone reaches its greatest width. From here it continues in a ventral direction pretty well perpendicular to the axis of the body. The caudal outer-zone is at the v. d. only 12 mm. wide.

If now we cast a glance at the entire strychnine-segmentzone, i.e. both inner- and outer-zone, we obtain the impression, that the two zones by which it is formed (both inner- and outer-zone) show an inclination to shrinking. In favour of this view plead: 1. the stronger converging of the limits of the inner-zone towards the ventral diameter, which reminds us of W. and v. R.'s central area; 2. the fact that the cranial outer-zone exceeds the caudal-zone especially in the ventral region; 3. the disappearance of a distinct "ventral crossed overlap"; 4. the fact that at the d. d. the zone is as wide as the former (VIII<sup>th</sup> Th.) and is here 34 mm., whilst at the v. d. the width is here 49 mm., consequently 6 mm. less.

If we may admit here on these grounds a first beginning of shrinking, then we are struck by the fact that the zone undergoes this diminution exactly in its most excentric part, namely in the "ventral-crossed overlap" and farther in the caudo-ventral region. In this way we obtain an insight into the manner in which the shrinking begins, and must observe then, that this shows conformity with what SHERRINGTON and W. and v. R. saw already in their root-fields.

We may consequently admit, that both the dermatomes and the strychnine-segmentzones, when they shrink, do so in the same manner, and both have their weakest point in the ventral-crossed overlap-region and in the caudo-ventral part.

### 3. *Strychnine-segmentzone of Th. VII right.*

As after the expiration of the above-mentioned determinations, the cat was still in a very good condition, I undertook the poisoning of another root, now on the right side of the spinal cord. I selected for this operation Th. VII, where I performed the application of the strychnine as carefully as possible, and did not cut the adjoining roots. I had previously convinced myself that to the right there was not a vestige of hyperreflexion in the skin. At the same time the first isolated root Th. VIII to the left was cut.

After the poisoning soon a distinctly hyperreflectory zone appeared that could easily be limited.

The zone had a great extent now, and no distinct contrasts between the inner- and the outer-zone could be discovered.

#### *Description of the total zone of Th. VII right.*

The cranial limit leaves the d. d. at about the level of the processus spinosus of the 7<sup>th</sup> thoracal vertebra, and runs almost perpendicularly to the axis of the body, with slight convexity in a caudal direction on the lateral surface. On the ventral surface it deviates again somewhat more in a cranial direction. The v. d. is reached 10 mm. cranially from the cranial limit of the left VIII<sup>th</sup> thoracal zone. (Comp. figure 3).

The caudal limit leaves the d.d. about 30 mm. caudally from the former and runs almost parallel with it with a slight inclination to diverging in a caudal direction. It reaches the v. d. together with the caudal limit of the left VIII<sup>th</sup> thoracal zone. (Compare the description given above and fig. 3). In the v. d. the width of the whole zone amounts to 43 mm. A ventral-crossed overlap could not be ascertained. This fact and likewise the comparatively slight width of the zone can justify the supposition that we have here to do with a beginning of shrinking, at all events the zone as strychnine-segmentzone has not the maximum extent which it can have. (Th. VIII on the left side was much wider). Although we have here not even to do with an optimum, I found, when exactly fixing the limits in the fixed bone-points under the skin, that the extent on the lateral surface answered already to above 3 ribs and the spaces between 3 ribs.



Such an extent is now the same as MERTENS could preparatorily ascertain as the norm for the trunk-dermatome of man.

The trapezium-shape answers likewise to the anatomical dermatome: all these proportions consequently plead strongly for the fact that my method is superior to the usual isolation methods, and strengthen the view, that the strychnine-segmentzone represents in fact the whole rootfield: the theoretical dermatome. If this is so indeed, we may likewise conclude that W. and v. R's view, that the central area and the whole dermatome have the greatest width in the lateral part, is not correct, but that the greatest width is reached at the v. d. <sup>1)</sup>.

At last we can try, by a comparison of the dimensions of the zones which we have found, to get an insight into the overlappings of the root-fields. With a view to this I begin to represent here all the dimensions found by me in a table likewise indicating those of the areflectory zone of the left side, situated between the isolated Th. VIII and Th XI.

	Width	d.d.	Lat. line	Pap. line	v. d.
Strychnine-segmentzone of Th. VIII.	inner-zone	30	30	24	23
	cranial outer-zone	2	7	10	10
	caudal outer-zone	3	13	16	21
Total width of the str.segm.zone		35	50	50	54
Areflectoric zone		11	6	10	10
Strychnine-segmentzone of Th. XI	inner-zone	32-34	28	26	16
	cranial outer-zone	?	17	15	21
	caudal outer-zone	?	10	12	12
Total width of Th. XI		34	55	53	49
Strychnine-segmentzone of Th. VII	total width of the zone	30	?	?	43

<sup>1)</sup> Compare: V. E. MERTENS. Ueber die Hautzweige der Intercostalnerve. Anatom. Anzeiger Bd. XIV. S. 74 Jena. 1891. MERTENS describes here the extent i.a. of the 4th intercostalnerve of man. He found: that the zone provided for by it: . . . "sich über drei Intercostalräume, und ebensoviel Rippen erstreckte, und zwar begann es mit dem dritten Intercostalraum, und endete auf der sechsten Rippe".

As it is known W. and v. R. indicate the overlapping of the central-area as  $\frac{1}{3}$  of the extent at the d. d. Further they found, in some of their cases, that the width of the analgic zone, the consequence of the cutting of two roots, was as wide at the d.d. as the sensible zone of one isolated root.

Let us now compare the results of the strychnine-segmentzones.

With regard to the proportion of the width of one total segmentzone to that of the areflectory zone of two cut roots we see that the proportion is here 30 : 15, thus instead of 1 : 1 they bear a proportion of 2 : 1. Of greater importance however is the overlapping of the strychninezones in their entirety, or, where they have taught us to consider them, identical with the theoretical dermatomes, the overlappings of the entire rootzones. W. and v. R. could not determine them, as is self-evident, because they always found large "marginal area".

If we apply now the method of calculation of the covering as indicated by the above-mentioned authors we find, if we call the overlapped field of the root-zones  $x$  and the not overlapped part  $y$ , that at the d.d. holds for the whole hyperreflectory zone

$$2x + y = 35 \text{ m.m.}$$

and the areflectory zone must be expressed as :

$$2y + x = 11 \text{ m.m.}$$

From this we can calculate the values of  $x$  and  $y$

$$\begin{array}{rcl} 2x + y = 35 & 2x + y = 105:3 & x + 2y = 33:3 \\ 2y + x = 11 & x + y = 46:3 & x + y = 46:3 \\ \hline 3x + 3y = 46 & x = 59:3 & y = -13:3 \end{array}$$

From which follows that

$$\begin{aligned} x : y &= 59 : -13 \\ y &= -\frac{13}{59}x = -\frac{2}{9}x. \end{aligned}$$

If now we suppose the whole root-zone = 1, then is

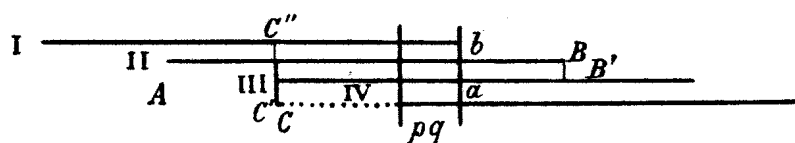
$$2x + y = 2x - \frac{2}{9}x = 1, \text{ consequently } 16x = 9, \text{ and } x = \frac{9}{16}.$$

From this follows that the rootfields cover each other at the d.d. for  $\frac{9}{16}$ . W. and v. R. had estimated it at about  $\frac{9}{15}$ , which agrees pretty well with my result.

From the construed figure (fig. 4) it appears that in the dorsal trunkskin, parts are alternately provided for by two and by three

roots. In the middle of each dermatome meet each other the outer extremities of the two adjacent zones, which overlap each other here for  $\frac{2}{16}$ . Here consequently a threefold root-innervation takes place. In the rest of the dermatome only two fields overlap each other.

Let us now execute the same calculation for the v.d. Here, as will be remembered, no areflectory zone was found. We can however make an analogous, though somewhat more complicated calculation, taking into account the ascertained overlapping of the zones of Th. VIII and Th. XI.



If we express now the width of the whole dermatome in the v.d. in the above indicated symbols, the width of a rootfield  $AB = Ab - B'C' - bC'' = 2x - y$ .

In the figure zone I represents consequently Th. VIII and zone IV Th. XI. As Th. VIII and XI overlap each other 10 m.m. I may suppose  $pq = 10$ . If now we call  $x$  the overlapping of two adjacent zones, and  $y$  the overlapping of two alternating zones, then we find for  $pq$ :

$$pq = Cq - Cp = C'a - bB \text{ as } Cp = bB$$

$$pq = y - (AB - Ab) \text{ as } C'a = y \text{ (namely the overlapping of I on III)}$$

$$pq = y - (2x - y - x)$$

$$pq = y - x + y = -x + 2y = 10 \text{ m.m.}$$

From this follows:

$$\begin{array}{r} 2x - y = 55^1) \quad -x + 2y = 10 \\ -2x + 4y = 20 \quad 4x - 2y = 110 \\ \hline 3y = 75 \quad 3x = 120 \\ y = 25 \quad x = 40 \end{array}$$

The overlapping of the immediately adjacent root-fields ( $x$ ) is consequently

<sup>1)</sup> I take here for the calculation the width of Th. VIII and not that of Th. XI, because I suppose that this zone had somewhat shrunk.

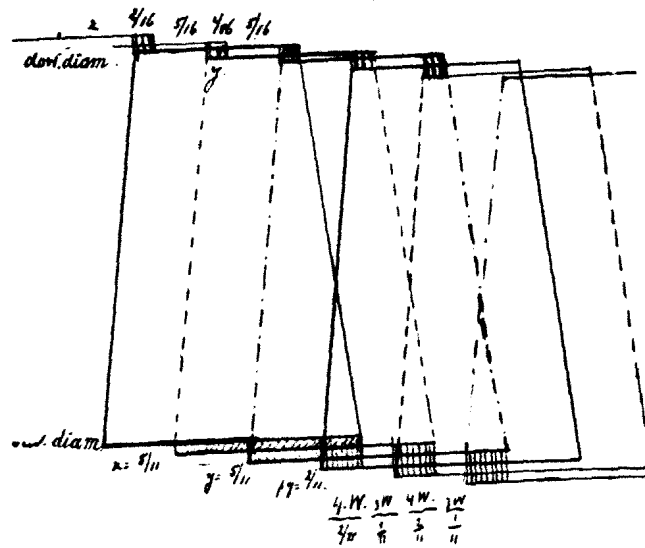


Fig. 4.

Scheme of the mutual overlappings of the dermatomes at the d.d. and at the v.d. (The dorso-ventral dimension has not been taken proportionally correct.

$\frac{40}{55} = \frac{8}{11}$ ; and the overlapping of a root-field with the third next one ( $y$ ) is  $\frac{25}{55} = \frac{5}{11}$ . At last the overlapping of a rootfield with the fourth ( $pq$ ):  $\frac{10}{55} = \frac{2}{11}$ .

W. and v. R. supposed that the rootzones overlap each other for one half, so that zone 1 should stand against zone 3. Consequently each skinpoint would be provided for by only two roots. From my statements it appears that the overlaps are much stronger, and that in some places even as many as four rootfields overlap one another. The arrangement is thus at the v.d. so, that here strips that are provided for by 2 borders of rootzones and by 2 more central parts of these, alternate with strips provided for by the more peripheric parts of three rootfields.

If we repeat the calculations given above likewise for the "inner-zones" of my strychnine-segment zones, then the overlapping of these at the d.d. appears to be not  $\frac{1}{3}$ , as W. and v. R. supposed, but  $\frac{1}{2}$ . At the ventral median line where W. and v. R. did not find an overlap of their central areas, the overlaps of the inner-zones appears to be about  $\frac{1}{5}$ . From this great difference between the results of

the usual method of isolation and mine appears again how strong a diminution of the limited value of stimuli is obtained by strychnine.

So far the facts. Now it seems not impossible to me to investigate, with the help of my results, somewhat closer some questionable points of the segmental innervation.

Let us begin with the well-known so called "LANGELAAN lines". According to this author<sup>1)</sup> one finds in the skin of normal persons hyperaesthetic lines and strings, which are said to exist in the intersegmental limits. From my calculations of the overlaps it might follow on the contrary, that there is a better foundation for admitting this hyperaesthesia in those strips of skin where always three (at the d.d.) dermatomes overlap each other. These strips however do not lie intersegmental in the sense of two immediately succeeding zones, but exactly opposite to the axis of a rootfield. At the same time they form the so-called intersegmental limit of each third dermatome. From this may, at the same time, be concluded that the distance between two "LANGELAAN lines" does not amount to the width of a dermatome, but to half the width. At the v.d. the proportions are too complicated for an analogous interpretation to be ventured.

For the much discussed territory of pigment-stripes of vertebrae the knowledge of the innervation-proportions of the skin, as it is now somewhat more detailed by the study of the strychnine-segmentzone, might prove useful. I have here specially in view the dark stripes of so many animals. SHERRINGTON<sup>2)</sup> has already called the attention to the fact that with zebra and tiger they seem to be segmentally arranged. VAN RIJNBERK<sup>3)</sup> considers the dark stripes as an expression of the stronger innervation which in his opinion can be observed in the intersegmental limits. By the overlaps of the central area a "summation" of the innervation is supposed to exist.

It is clear that to this view may be applied likewise what I said already above with regard to the "Langelaan-lines". Then VAN RIJNBERK's excess-contrasts might be arranged in those strips where the extreme borders of the alternating dermatomes overlap one another.

At last we may here fix the attention of the proportion in length of the short basis of the trapezium-shaped dermatome (in the d.d.) to that of the long basis in the v.d. This proportion is in Th. VIII

1) J. LANGELAAN. On the determination of sensory spinal skinfields in healthy individuals. These Proc. of 29 Sept. 1909 Vol. III.

2) C. S. SHERRINGTON. l. c. p. 737.

3) G. VAN RIJNBERK De huidteekeningen der gewervelde dieren in verband met de segmentaalleer. Verslagen der K. Akademie v. Wetenschappen te Amsterdam, 30 Sept. 1905.

zone here described, as 2 : 3. (In reality the proportions were 35 : 55). It is certainly peculiar, that this proportion 2 : 3 expresses exactly the "stretching" of the ventral skin (from manubrium to symphysis) with regard to the dorsal one from the first to the thirteenth thoracalvertebra. I could find for the cat about the same proportion, given by SHERRINGTON for *Macacus*.

*Summary :*

I. In favourable cases the strychnine-segmentzone has the exact shape, and most likely also entirely the same extent as the theoretical dermatome. It has then the shape of a trapezium, the short basis of which lies in the dorsal, and the long basis in the ventral body-diameter.

II. The strychnine-segmentzone consists of two parts which are sharply to be distinguished: an "inner-zone" that becomes sooner hyperreflectory, and remains stronger, and an "outer-zone" that appears later and remains less hyperreflectory. This behaviour of the strychnine-zone is consequently analogous to what SHERRINGTON and especially W. and v. R. communicated already about the sensibility in the dermatome that they had investigated by the isolation-method.

III. The vulnerability of the strychnine-segmentzone shows likewise great correspondence with that of the isolated root-field; they begin to shrink in the ventral overlapzone, and in the caudo-ventral part of the zone. Moreover they offer like the root-fields the peculiarity, that when shrinking, the innerzone analogous to the nucleusfield, becomes smaller, to the advantage of the outer-zone, analogous to the border-zone.

IV. In consequence of all this we may admit that the other proportions found for the strychnine-segmentzone, hold likewise for the dermatomes, that is to say :

the overlapping of the d.d. amounts to  $\frac{9}{16}$  and at the v.d.  $\frac{8}{11}$ . By this the skin is alternately provided for : at the d.d. for  $\frac{2}{16}$  by three roots, and for  $\frac{5}{16}$  of each dermatome by two roots ; and at the v.d. for  $\frac{2}{11}$  by four roots, and for  $\frac{1}{11}$  of each dermatome by three roots.

V. The "Langelaan lines" and VAN RIJNBEEK's "excess-contrasts" by summation most likely answer to the strips of skin, where, at the dorsal diameter, the innervation takes place through three roots. If this hypothesis might be confirmed we should in the mentioned skin-stripes really possess a means of fixing the dermatome limits, as between every two such like alternating stripes, exactly a dermatome would be situated.

I. J. H. M. KLESSENS. "From and function of the trunk-dermatome tested by the strychnine-segmentzones".

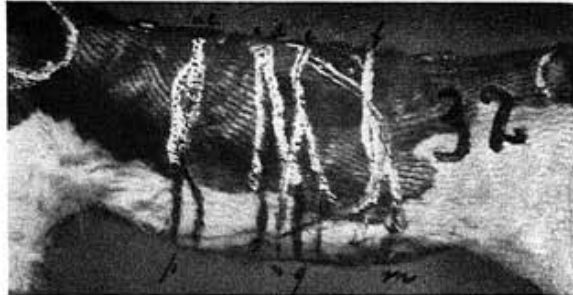


Fig. 1. Left side of 32. Inner- and outer-zones of Th. VIII. (*a d p q*) and of Th. XI. (*e f m n*).  
(Indicated the arcus costarum and the scapula and the crista ilei)

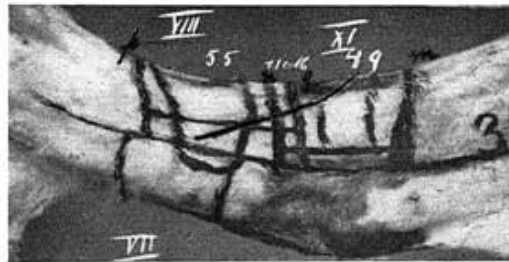


Fig. 2. Ventral side of cat 32. To the left the inner- and outer-zones of Th. VIII (*p q*) and of Th. XI (*n d*).  
To the right the total zone of Th. VII.



Fig. 3. Right side of cat 32. Strychnine-zone of Th. VII.  
(Indicated the arcus costarum and the scapula).

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**Microbiology.** — "*Action of hydrogenious, boric acid, copper, manganese, zinc and rubidium on the metabolism of Aspergillus niger*". By Mr. H. J. WATERMAN. (Communicated by Prof. M. W. BEIJERINCK).

(Communicated in the meeting of Oct. 26, 1912).

RAULIN's object when examining the culture conditions of *Aspergillus niger*<sup>1)</sup> was to obtain the greatest possible weight of mould.

The experimenters who after him occupied themselves with this question, likewise only considered the dry weight.

Such an investigation must needs be partial as the process of the metabolism is only roughly determined by the weight of mould. For a good insight into this process it must be observed that for instance the spore formation produces differences in the chemical composition of the obtained mould materials.

Hence, the changes of the plastic aequivalent or of the assimilation quotient should be determined many times in the course of the development; first of all of the carbon then of the other elements.

In an earlier paper<sup>2)</sup> I proved that changes of temperature and concentration do not modify the metabolism of the carbon and that only the velocity of this process is subject to modification.

At present I have studied the influence of various chemical compounds.

#### 1. *Action of different rates of hydrogenions.*

The results of the referring experiments are found in Table I.

We see from it in connection with the incorrectness of these observations, caused by the small quantity of mould, that the plastic aequivalent of the carbon, in spite of the slackening of the growth and sporeforming, caused by the hydrogenions, does not undergo a convincing change.

#### 2. *Action of different boric acid concentrations.*<sup>3)</sup>

Analogous results as for the hydrogenions were found with boric acid as seen in Table II.

In lower concentrations of about 0,06% the plastic aequivalent remains almost unchanged.

The slight lowering observed at higher concentrations may be

<sup>1)</sup> J. RAULIN, Etudes chimiques sur la végétation, Paris 1870.

<sup>2)</sup> H. J. WATERMAN, Beitrag zur Kenntnis der Kohlenstoffnahrung von *Aspergillus niger*, Folia Microbiologica, Holländische Beiträge zur gesammten Mikrobiologie 1912 Bd. I p. 422.

<sup>3)</sup> Also compare: J. BÖESEKEN and H. J. WATERMAN, Folia Microbiologica I (1912) p. 342.