Physiology. — *"Rolling movements, and the ascending vestibulary connections. (Fasciculus Deiters Ascendens.)* By Dr. L. J. J. MUSKENS [1]). (Communicated by Prof. J. K. A. WERTHEIM SALOMONSON).

(Communicated in the meeting of April 25, 1913).

By rolling movements we intend to have understood, the complex of symptoms that I described under the name [2]) of rolling movements, so that this forced movement was reckoned to be present, as long as the head was rotated around the bodily axis (cervical spine) and there is still present an apparent tendency to lie down on one side, and inclination to fall down on that side. We deal here therefore with a locomotion, or tendency to locomotion, in a vertical plane, standing vertical to the long axis of the body.

I have arranged a great number of experiments, about the N. vestibularis especially on cats, after the anatomical lesions, found with the MARCHI method after death.

In a first group the cases, where the vestibulary root itself was wounded by the instrument, or was found degenerated at least to such a point (by stretching, cerebral haemorrhage) in such an intensity that a very serious lesion of the root either partial or total must have been present. The supposition of this serious lesion of the vestibulary nerve when finding compact degeneration of the root gains in probability, as soon as one compares the duration of the rolling movements in this group with the duration of this movement after other lesions, as also with the duration of the circusmovement in a former publication. [3]) Then one is struck by the far longer duration of the forced movements, after direct lesion of the vestibulary nerve, i.e. in the cases with anatomically certified degeneration as above was alluded to. Practically in cats only after direct lesion of the vestibulary nerve during weeks rolling movement can be found; after lesion of the vestibulary nuclei, and a fortiori of the ascending systems only the formerly described minor conditions of the forced movements can be found.

If we study up this first group, at once we are struck with the fact, that without exception the rolling movement is performed, in the same direction i.e. in such a way, that the locomotion always

[1]) (In this paper. a translation of the one that was communicated April 25, 1913, the author has introduced considerable additions and alterations).

[2]) Journal of Physiology XXXI, 1904 p. 204—221.

[3]) The posterior longitudinal fascicle and the circusmovement. These Proceeding 26 Oct. 1912, and Neuraxe 1913, p 727.

takes place, to the side of the lesion. [1]) Usually shortly after the operation a rotation of the eyeballs around their anteroposterior axis in the same direction is present and also mystagmiform movements of the eyeballs, slow in the sense of the rotations and rapidly back to the normal position (loc. cit.).

In the latter stages the only sympton recalling the movements is a tendency to lie down on the operated side, or even a slighter resistance, if one tries to push the animal on that flank.

All this is in accordance with the older experiments of FLOURENS, SCHIFF and CYON and the more recent ones of EWALD, WINKLER, BARTELS etc. about lesions of the semicircular apparatus and section of the N. acustico-vestibularis.

As soon as the rolling movements are completely compensated, it is easy by blindfolding the animal, by causing an emotion or by the dropping experiment of MAREY (the normal animal lift up by its feet and dropped unvariably comes down on its feet) to bring about again the original rotation. Also in epileptic fits the rotation may reappear. It is peculiar that in ether-narcosis sometimes a rotation in the inverse sense was noted. [2])

All this being the rule for experimental animals, whether it be exclusively the vestibulary root, or also the acoustic nerve, the tuberculum acusticum, the corpus restiforme and the crus medium cerebelli, are simultaneously hurt, for the anatomical connections of the N. Vestibularis those individuals especially have value, whereby — more or less by accident — exclusively the vestibulary root was partly or totally degenerated.

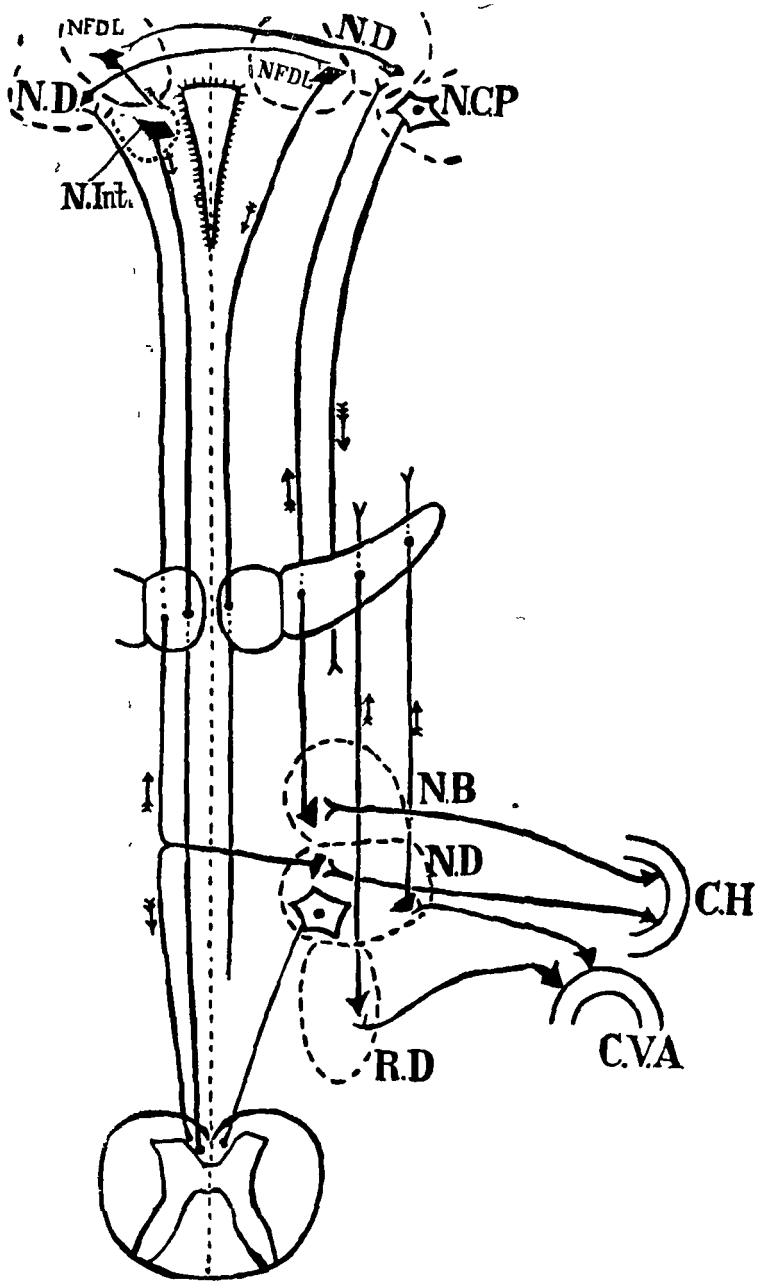
Here I must mention rabbit V, where the pars petrosa cerebelli was extirpated and as an exclusive associated lesion the N. Vestibularis happened to be hurt. Here we could follow up the degenerated nerve-sheaths pre-eminently to three celgroups: to the triangular part of the DEITERS Nucleus and its descending Ramus, to the

[1]) The direction of the locomotion associated with the forced movements, is judged by the original position of the animal itself. As also this does not preclude the mixing up of these conditions (e g. a sick person, lying in bed on the back-side, presents negative geotropy, compared with all other mammals), the primary position of the animal is always reduced to that of the simplest vertebrate with the simplest forced movements, viz of fishes. This detail will prove of importance as soon as we proceed from the analysis of the forced movements towards that of the various pathological conditions of the ocular movements and towards that of the various pathological conditions of the ocular movements, conjugated deviations and other neurological syndroms.

[2]) Compare RISIEN RUSSELL, Phil Transaction CL XXXV, p. 837, 1894 and ROTHFELD PFLÜGER's Archiv. Vol. 49, p. 440 1912.

medio-dorsal group and to the region of the Nucleus BECHTEREW- and the Nucleus Tecti.

In none of the animals of this first group degeneration was found,



either ascending or descending, into the area of the P. L. B. (Posterior Longitudinal Bundle) its lateral wing, the so-called F. D. A. (Fasciculus DEITERS Ascendens).

In the second group we bring the cases, where there was possibly some lesion of the N. vestibularis, recognisable by a less compact degeneration in that nerve and certainly not caused by a direct lesion, but by an indirect one as shifting of the cranial contents, vicinity of an malacial hearth and also by retrograde degeneration. In this it strikes us, that the N. Vestibularis appears not only to be exposed to an associate lesion after an operation in the posterior cerebral cavity, but that also the vulnerability of this cerebral nerve is observed after lesions of some distant structure.

We have to stand still with the three cases (107, 108, 109) where the region of the posterior commissure was wounded.

In these cases the forced movements cannot be considered as having the same origin. In cat 108 the dependence of the rolling and circus movement to the left on the degeneration found in the vestibulary nerve is most conspicuous, because in this case no degeneration in the secondary vestibulary system was found. On the other hand we find in 107 a slight, even doubtful, degeneration in the L. vestibulary nerve, which cannot be considered responsible for the long lasting circus movement to the R. nor for the long lasting rolling movement to the L. As we saw in a former publication [1]) the descending degeneration of the most medial segment of the P. L. B. on the operated side is most common [2]) in animals, where a lesion of the region of the posterior commissure was performed and circus movement ensued to the operated side.

For some time I considered the rolling movements to the L. dependent on the centrifugal degeneration of the bundle, lateral to the P. L. B. (PROBST)[3]) particularly because also one of KARPLUS and ECONOMO's [4]) animals had shown after a similar lesion rolling movement (and the position in that sense) to the normal side; equally in this animal this bundle was found degenerated.

Later experience however leads me to doubt whether this bundle has anything to do with the forced movements. Also regarding the bundle that degenerates within the area of the P. L. B. from the interstitial nucleus far down the spinal cord (interstitio-spinal bundle) I am not in the position to deny nor to affirm its relation to the vestibulary system, and physiologically spoken to the forced movements. The fact, that in 2 cats (107 and 108), which performed

[1]) Comp. Transactions Royal Dutch Academy 26 Oct. 1912 p. 727.

[2]) Compare BOYCE. Neurologisches Centralblatt. 1894. p. 467.

[3]) Jahrbücher für Psysichiatrie und Neurologie 1903. Vol. 23. p. 17 and Deutsche Zeitschr. f. Nervenheilk. 1900. Vol. 17. p. 156.

[4]) Archiv für Psychiatrie Vol. 46 page 393.

during the longest period rolling movements, tends to throw some doubt on the interpretation, presented above, viz. that the secondary lesion of the vestibulary roots might alone be responsible for these disturbances. It suggests the possibility, that this interstitio-spiral bundle, descending low down the cord, might represent the efferent tract for the rolling movement, as we saw the commissuro-medullary bundle did for the circusmovements. The vulnerability of the vestibulary nerve to distant lesions renders the analysis, of this sort of functional disturbances viz. rolling in their relation to the anatomical findings extremely delicate. Not only in lesions of the Mesencephalon and of the Cerebellum but also after a lesion caudal to the exit of the 8th nerve (as in cat 145) this nerve root may be indirectly hurt.

These indirect lesions (by shifting of the cranial contents etc.) produce functional disturbances of the same order as those observed after direct lesion of that nerve. This is proved by the fact that practicaly only rolling movements ensue, which take place towards the side on which the black particles are found, particularly in the fan-like part of the intra-medullary course of the vestibulary nerve, after having passed the narrow passage between the corpus restiforme and the descending 5th Nucleus. It is remarkable that in all cases the indirect vestibulary lesion was found on the contra-lateral side of the primary lesion.

The duration of the forced movements after indirect vestibulary lesion, is naturally far less than after a primary lesion [1]).

Finally it is interesting to know that in my lesions of the region of the posterior commissure only in 109 some slight degeneration in the lateral part of the Fasciculus Deiters Ascendens (LEWANDOWSKI, WINKLER) was found. I think it allowed to infer from this fact that solely in this case also Deiters Nucleus had undergone some secondary changes, of which some black particles in that structure give evidence.

I also think we may infer that the vestibulary nerve itself is far more vulnerable, than its nuclei and ascending connections, independent of the fact, that — as I have proved — the forced movements (rolling) observed after direct vestibulary lesion are of a far more vehement character than after a lesion of its secondary connections.

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[1]) It is probable, that in human pathology a good part of the most common symptoms of increased cerebral pressure (dizziness), reflectory disturbances of the ocular movements, falling sidewards) will prove to be the result of a simular indirect vestibulary lesion, this nerve being after these experimental results far more vulnerable than its secondary intra-cerebral connections.

Rabbit I in group 2 of VAN VALKENBURG is interesting. The brain was stained after WEIGERT-PAL. Besides the atrophy of GUDDEN's nucleus, on the side of the lesion, described some time ago, in a reconsideration of the series of slides this author and myself could convince us of a decided diminution in size of the same sided P. L. B.-formation, in the pontine and medullary region. This case, therefore seen the decided tendency to roll to the right side, as noted down by Dr. VAN VALKENBURG, comes in the line, I think, of experiments 107 and 108, in suggesting the possibility, that the tr. interstitio-spinalis might represent the descending limb of the reflex-mechanism, dealing with the rolling to the intact side; in the same way as, after my former communication (October 1912) the commissuro-medullary bundle represents the descending limb of the reflex-mechanism, controlling the circus movement to the side of the lesion.

Next follow in my table three cases, where the region of DEITERS Nucleus was wounded and at the same time the vestibulary radiation on one or on both sides was not found free from degeneration [1]). The rolling movements, observed in these cases (in its rudimentary manifestations lying on one side, falling to one side, rotation of the head around the neck to one side) agree with those observed after lesion of the vestibulary nerve.

As in these cases we have to deal with a gross lesion of the nuclei, the secondary ascending DEITERS-connections are not found free from degeneration. Again, for the anatomical-physiological analysis these cases are of little use, as such complicate lesions do not allow of any safe conclusion.

After my former communication about the circusmovement, which disturbance in its pure form was never observed by me as a result of direct lesion, we cannot but ascribe the circus movement to the right side in 113 and 118 to the lesion of DEITERS Nucleus on the right side and the degeneration in the crossed ascending P.L.B.-Bundle.

Complicated lesions we find also in group 3. It cannot be said that in any animal one cellgroup only, of DEITERS Complex was hurt. Solely in VIII and 99 we find a lesion limited to the Ramus Descendens of the Vestibular Nucleus. Here it is remarkable, that both animals, notwithstanding important differences in extension of the lesion, yet have shown the same type of rolling movement, viz. to the *normal* side. Here it must be recalled, that in none of my experiments with direct or indirect lesion of the nerve itself this

[1]) This is the reason why it is not possible to attempt in this sort of experiments the physiological analysis of the different parts of DEITERS-Complex.

rolling to that side was observed. Also it strikes us that in both cases, no trace of degeneration in the P.L.B., and the F.D.A. was found. Also in an other experiment the degeneration is found in the Ramus descendens and also this animal made in the latter days of its life rolling movements to the healthy side.

Also after sagittal lesions, immediately lateral to the P. L. B., I observed a tendency to fall on the normal side. In this point case 146 and 158 complete each other very well. In 158 the extensive sagittal lesion cuts off the whole of the DEITERS Complex from the raphe; in 146 the smaller and more caudal sagittal lesion begins exactly distally from the striae acusticae (MONAKOW). In both cases during a longer (158) and shorter (146) period a tendency to fall to the normal side was noted. Only in the proximal lesion we find the degeneration in the medial part of the F. D. A. In 146 nor in the Ramus descendens nor in the F. D. A. a sufficient degeneration is found, to be held responsible for the "Slight tendency to fall to the right side" as was noted some days after the operation. It may be supposed, that the sagittal haemorrhage on the lateral side of the P. L. B. by mechanical compression should have interfered with the function of the Ramus descendens and the Nuc. DEITERS, irritating it, but not causing the dissolution of medullary sheaths. In the case of 158 in accordance with the crossed ascending vestibulo-mesencephalic bundle in the P. L. B. during 9. days circus movement to the normal side was noted; in 146 only during a few days some tendency to it. That the crossed ascending vestibulo-mesencephalic bundle not exclusively must be limited to the areal of the P. L. B. proper, we find confirmed not only in 158, but also in 113.

The cases, which we have combined in group IV, (direct lesion of the P. L. B. system) can be divided after the physiological data into 2 subgroups. The first subgroup contains 7 animals, which during several days performed rolling movements to the *side of the lesion.* In all these animals the F.D.A. was either directly hurt by the lesion or was found in a decided state of degeneration, viz. as a result of lesion in the region immediately oral to the DEITERS-complex. The black granules as a proof of an intense ascending degeneration (descending fibres are never found in the F.D.A.) we find only in 92, 93 and N°. 3 (Series of Besta) spread over the whole area; in the other cases exclusively the lateral half of the F.D.A. is found degenerated, in 3 cases as a result of direct traumatical destruction of that part. Very instructive is in this regard 150, where exclusively the most lateral part of the F.D.A. was hurt about the Corpora quadrigemina posteriora, together with parts that

have certainly nothing to do with forced movements and secondary vestibulary connections. Very instructive is furthermore the comparison of 90 and 92; in both cases both P.L.B. are cut through, but in one case simultaneously the right F.D.A., in the other one the left F.D.A. is severed. The rolling movements in all these animals were to the side of the F.D.A. that was degenerated, in toto or in the lateral part.

All lesions in this undergroup, are found in the F.D.A. between the proximal part of the DEITERS-Complex to the oral termination of the F.D.A., lateral to the trochlear nucleus. A destruction of the distal parts of DEITERS-complex (95) causing no degeneration of this area, I hold that the fibres of the F.D.A. arise in the medial and proximal cellgroups of DEITERS nucleus. LEWANDOWSKY and C. WINKLER also indicate, that the Fasc. DEITERS Ascendens exhausts itself in the 4th and 3d nuclei.

For comparison also 139 is placed in this series, because in this animal, exclusively the left posterior longitudinal bundle was cut, resulting in uncommonly long lasting circusmovement to the right side (10 days). There was however no trace of rolling movements. In the second undergroup (group IV) four animals are brought together, in which rolling movements to the *normal side* were observed after direct lesion of the F.D.A. Also in these animals it could be practically excluded, that the N. vestibularis or its Nuclei were hurt and could be held responsible for the forced movements, observed during life. As in these animals (158, 91, 68, 221 and also 5 (ECONOMO and KARPLUS)) we find exclusively degeneration of the medial part, of the F.D.A., I think we may infer that in this part of the areal fibres are abundant, which represent the ascending connections of the Ramus descendens Nuc. Vestibularis. It will be recalled, that a lesion in this latter cellgroup causes equally rolling movements to the *normal side*. It is interesting that in cat 68 a maximal rotation of the head towards the *normal side* was observed, being a result, I consider, of the haemorrhage, that was located in the middle part of the F.D.A.

In a scheme I have tried to render conspicuous the results of this investigation. If we compare these data of the physiological analysis of the ascendent connections of DEITERS-complex, with what we know from FLOURENS, SPAMER, CYON, EWALD, BARANYI, CAMIS and others about the function of the semicircular canals, there can be hardly any doubt, that for the rolling movements, we have to look to the anterior vertical canal as its source of centripetal impulses. As we have found two bundles in the F. D. A. of which a lesion causes

either rolling to the affected or to the normal side, it seems not very risky, to admit 2 connections from this canal to separate cellgroups in DEITERS-complex. As Marchi-preparations do not allow a further analysis of the nuclei, we can only suppose, that the Ramus descendens Nuc. Vestibularis controls the rolling to the normal side, the more proximal part of DEITERS-complex the rolling to the affected side.

Equally for the circus-movement a similar arrangement can be recognised. An important difference is only this detail, that one of the two ascending connections of the cellgroup, that controls the circus-movement to the affected side, crosses the raphe.

The whole of the posterior longitudinal bundle together with its lateral wings (F. D. A.), we find thus composed by 2 descending and four ascending systems of fibres. The two innermost bundles are descending ones from the nuclei of the posterior commissure, the medial one degenerating to the medulla, the lateral one to far down the spinal cord. The first one (commissuro-medullary bundle) is found degenerated after the lesions in the region of the posterior commissure, that had caused circus-movement to the affected side. The second bundle (f. interstitio-spinalis) has probably nothing to do with the forced movements.

The middle part of the entire P. L. B. system is composed of two ascending bundles, originating in DEITER's complex. The innermost, more voluminous one, contains crossed fibres, F. vestibulo-mesencephalicus cruciatus, the lateral one homolateral fibres (F. Vestibulo-mesencephalicus homolateralis).

After section (and ascending degeneration) by a lesion of the DEITERS' complex of either of these bundles circus-movements to the normal side are performed.

The outmost part of the P. L. B.-system is composed of two ascendent bundles either of them originating in the DEITERS' complex and terminating in the tegmentum little beyond the level of the trochlear nucleus. The outmost of these two bundles (probably from the proximal parts of DEITERS' complex) elicits by its ascending degeneration rolling movements to the affected side (F. vestibulo-tegmentalis lateralis), that of the innermost one (probably arising from the Ramus descendens) rolling movements to the normal side (F. vestibulo-tegmentalis medialis).

As far as I can judge, the relative situation of these bundles is pretty constant, but the ascending fibres intermingle more than the descending ones. Not rarely the bulky crossed vestibulo mesencephalic bundle holds in the cross-section an area far beyond the P. L. B. proper.

If we compare from the physiological standpoint the duration and the degree of the circus- and rolling-movements after lesions of the peripheral organ (semi-circular canals), the vestibulary nerve, of its nuclei and of the ascending connections, we are struck by the difference in the results. Vehement forced movements and, peculiarly enough only rolling movements to the affected side, are exclusively found after lesion of the vestibulary nerve. Especially so in the lower vertebrates as the rabbit and cavia. A lesion of the nuclei is followed by less vigorous forced movements, mostly of mixed type, rolling-movements combined with circus-movements. According to the nuclei involved, all combinations may occur, together with the corresponding conjugated deviation of the eyeballs.

After a lesion of the ascending connections, it is due to the anatomical arrangement, that circus-movements to one side and rolling-movements to the other side combined, will prevail. Although in a measure the degree and duration of the forced movements and concomitant symptoms (falling aside, conjugated deviation), is dependent on the quantity of the fibres degenerated, it appears, that the compensation is arrived at the more early, the more central the lesion is situated.

In so far the extraordinary sensitiveness of the vestibulary trunk cannot cause astonishment, as from clinical experience there is sufficient reason to expect an uncommon irritability of that nerve (HIDZIG's vertigo by galvanisation of the head, the frequency of dizziness in cases of tumour cerebri not only of the posterior fossa cerebri but also far distant).

From my experiments I conclude, that the forced movements are the result of an irritation, caused by the degeneration of the medullary sheaths. If an haemorrhage occurs in the area of the P. L. B. system, the forced movements show an uncommon vehement character and last longer; but finally, after complete destruction of the nerve fibres and after the process of compensation is set in action, all traces of spontaneous forced movements disappear and can only be elicited after certain measures (blindfolding, narcosis, mutilation of the cerebral hemispheres).

Although the 2 types of forced movements, which until now (viz. locomotion in the horizontal plane and in the plane vertical to the long axis of the animal) show many points of comparison, they cannot be looked upon as quite similarly arranged mechanisms. Not only is there disagreement in anatomical arrangement of the ascending bundles, but we also failed to find a distinct centrifugal bundle in the P. L. B. system, whose descending degeneration causes

rolling movement. It will be recalled, that for the forced movement in the horizontal plane (circus-movement) the Commisuro-medullary bundle fills up that gap. In this bundle we can recognize SHERRINGTON's "final common path", by whatever reflex-arrangements the circus movement (with the conjugated deviation of head and eyes) is provoked.

As a general result it may now be safely concluded, that my supposition of 1902 [1]) proved right, that the P. L. B. system plays an important rôle in the physiology of the forced movements, in the horizontal plane (circus) and in the vertical plane, standing vertical to the bodily axis (rolling). Long before this BLEULER, DUVAL and LABORDE, CAYGAL, EDINGER HELD, BOYCE [2]) et al. had hinted to such a relation; BLEULER had directly urged the need of experimental work on the P. L. B., which as far as I am aware till now has been neglected. Advancing knowledge of anatomical connections has, for many years, made it probable, that ascending vestibulary neura split up in particular divisions of the Oculomotor Nuclei (WALLENBERG [3]). Descending fibres in the P. L. B. were demonstrated by VAN GEHUCHTEN [4]) GEE and TOOTH [5]) and KOHNSTAMM [6]) down to the lumbar region. PROBST, SPITZER, L. KAPLAN and L. FINKLENBURG [7]) proved, that the ascending fibres were of vestibulary origin and thence declared their function, to be of equilibratory character. MONAKOW, FERRIER and TURNER, LLOYD THOMAS, LEWANDOWSKY, WINKLER and VAN GEHUCHTEN added materially to our knowledge of the anatomical analysis of the P. L. B. formation. PROBST discovered that from BECHTEREWS nucleus most ascending fibres are homolateral and WALLENBERG succeeded in showing in birds, that the innermost fibres in this structure are derived from the contralateral vestibulary nuclei. Yet, the physiological analysis of this region made very little progress. As to the descending tracts to DARKSCHEWITCH [8]) BOYCE, REDLICH [9]) we owe details about the grey masses about the posterior commissure, but no special research was reported about the accurate relation of these nuclei and the descending fibres in the P. L. B., as far as I am aware. It may be observed that only recently CAYAL's accurate description of this region in the chicken and FUSÉ's detailed account, from MONAKOW's laboratory, on the vestibulary nuclei, as also HORSLEY and CLARKE's researches have cleared the road for the physiological analysis.

[1]) Transactions Royal Dutch Academy 1902.
[2]) Philosophical Transactions 1898. Vol. 186. P. 325.
[3]) SCHMIDT's Jahrbüchen. 1899.
[4]) Academie royale de Belgique. 1895.
[5]) Brain. 1898.
[6]) Monatschrift f. Psychiatrie und Neurologie. 1900. Vol. VIII.
[7]) Monatschrift f. Psych. u. Neur. 1900. Vol. VIII. P. 210.
[8]) PFLÜGER. Archiv. Vol. 36. P. 639.
[9]) Monatschrift f. Psych. u. Neurol. 1899. Vol. V. P. 119.

Now it is interesting to note, that in this latter period fresh additions to our knowledge of the physiological function of this important structure (P. L. B. formation) came from quite other quarters, viz. from clinical anatomy. As I wish to reserve a detailed account of these data for another occasion, I will confine myself to stating, that the wellknown symptom of conjugated deviation — being a subphenomenon of the symptom of circus movement — appeared to stand in a direct relation to a lesion of the P. L. B. in such a way that destruction of the right P. L. B. caused conjugated deviation to the left. As we saw in a former publication [1]), by purely physiological and anatomical methods practically the same conclusion was arrived at for circus-movement in the cat. It cannot be denied, that both lines of thought complete each other very nicely. The old law of SCHIFF-PROBST ("A hemisection of the pons causes circus movement to the normal side; of the mesencephalon to the affected side") had, so it appeared, to be read in this way: a section of a P. L. B. results in circus movements to the non-sectioned side; a lesion of the posterior commissure results in circus-movements to the affected side".

The further physiological analysis of the lateral wings of the P. L. B. formation in cats, as we have attempted in this paper, discloses at all events the important fact, that this part of that structure holds fibres of equally vestibulary origin, but of different function. The degeneration of these tracts brought about either by direct lesion or by a lesion of its nutrient grey matter, results in forced movements in another plane, viz. rolling-movements, and the allied conjugated deviation, the MAGENDIE-HERTWIG squint. Here the relation between the ascending and descending tracts, controlling these movements, became not so transparent, as was the case with those controlling the circus-movement.

For the latter we found, that the gray matter near the posterior commissure was at the same time the endstation of the ascending tracts and the origin of the descending tract. For the rolling-movements it was proved, that the ascending bundles terminate in the tegmentum near the IV Nucleus, whereas we could only hesitatingly indicate one or two paths, that might be considered as the corresponding efferent tract. In another publication I intend to deal with those ascending vestibulary connections, whose lesion causes forced movements in a third plane (the vertical plane, that coincides with the long axis of the body) viz. staggering and culbutation. Proof will be forthcoming, that they run in entirely different structures as those, dealt with in this and the former papers.

[1]) Transactions Royal Dutch Academy. 25 Oct. 1912 and Neuraxe 1913.