THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY, WITH A NOTE ON THE MORPHOLOGY OF THE CHOROIDAL ARTERIES

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INTRODUCTION

There has never, as far as I am aware, been any controversy as to the source from which the lateral geniculate body receives its blood. Duret published in 1874 (1) the results of his researches into the blood supply of the brain generally and states that the lateral geniculate body receives its blood solely from the posterior cerebral artery, either directly, or indirectly *via* the posterior choroidal branches. His results have been confirmed or contradicted for many regions by later workers (Heubner, Kolisko, Beevor, Aitken, Stopford, Shellshear), but his description of the vascularisation of the geniculate body has been practically unchallenged. In the same year Heubner (2) announced the findings of his own researches, anatomical and pathological, in this field, but, while he contradicts Duret on many points, he asserts that the posterior cerebral artery alone is concerned with the lateral geniculate body.

In 1891, Kolisko (3) studied the distribution of the anterior choroidal artery in its relation to the posterior limb of the internal capsule. He was concerned mainly with the internal capsule and mentions the lateral geniculate body in only a few of his injections. There was, apparently, no doubt in his mind that the posterior cerebral artery was chiefly involved, and in injection 12 he discusses the relation of the anterior choroidal artery to the lateral geniculate body thus: "ein Injectionsstreif, welcher um das Corpus geniculatum laterale aussen herumzieht und bis ans Unterhorn reicht...." In no case did he obtain injection of the lateral geniculate body through the anterior choroidal artery. In addition, Kolisko collected two cases of occlusion of the anterior choroidal artery: in one, the obstruction was at the origin of this vessel, in the other, at its terminal branches. In the former, of which he gives the clinical findings, there is the specific statement that there was no interference with vision; in the latter, clinical data were unobtainable.

In 1905, von Monakow (4), in his discussion of the blood supply of the brain, states: "So wird z.B. das Corp. genicul. ext. nicht nur von einem Seitenast der hinteren Hirnarterie, sondern auch von Abzweigungen aus der dem Carotisgebiet entstammenden Art. chorioidea mit Blut gespeist" (p. 1085). This interesting statement is not, however, further expanded.

The whole problem of cerebral arterial supply was reinvestigated by

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Beevor (5) in 1909. As the result of his study of nearly one hundred brains, Beevor was able to publish very complete charts of his findings, and these have been the accepted standard until recent times. In twenty-three cases the anterior choroidal artery was injected individually, and in four of these the lateral geniculate body was reached, but not in the remaining nineteen. This fact Beevor records, but he finally concludes that the lateral, like the medial, geniculate body receives its entire blood supply from the posterior cerebral artery; nor does he attempt to explain his four discordant results.

Recently, Dr Ivy McKenzie of Glasgow reported a case wherein the post-mortem findings threw doubt upon the generally accepted view that the lateral geniculate body was entirely vascularised by the posterior cerebral artery. He communicated his anomalous results to Prof. Elliot Smith of University College, London, and it is to the kind suggestion of the latter that I am indebted for the opportunity of making this fresh study of the problem. This case is, I believe, the first of its kind to be described and, although Dr McKenzie is reporting it in full elsewhere, I shall give the history here because of its importance:

Mrs C. 41 years: always enjoyed perfectly good health, although slightly nervous for the last two years. One child, six years, and baby born on 28. iv. 31. No miscarriages. Children both healthy. Although nervous for two years she had no pains or disability of any kind. In the beginning of March, 1931, two months before the birth of the baby, she felt her right hand become weak and shaky. She also became sleepless and went off her food. The hand became worse and in a week or two the right leg began to drag, and about the beginning of April the eyes became affected and there seemed to be a film before the eyes.

After the birth of the child she became worse. When she was seen on 2. v. 31 she complained of pain at the back of the neck and said that she felt as if the upper part of the eyesight was affected when she looked at objects above her own height. She could not hold things comfortably and she could not recognise objects in her hands when her eyes were closed. Tactile and spatial discrimination were defective in both right hand and foot, and cutaneous sensation was dull all down the right side of the body. The reflexes were exaggerated both in the arm and the leg, and there was paresis of the right side of the face. This paresis was definitely of the organic type (Babinski, Clonus).

There was no ocular palsy; the fundi were normal; there was contraction of the field of vision. The Wassermann reaction was positive. Anti-syphilitic treatment caused improvement. She was able to walk without any appearance of lameness and by the end of June the power had been restored to the right hand for all ordinary purposes. She still complained about her eyesight, became very depressed and ultimately took her own life by lysol. The eye chart by Dr Meighen showing the visual defect was made on the day before she took her own life.

The eye chart referred to shows great visual loss in the upper half of both fields, but is more complete towards the left on both sides. There is, in addition, slight concentric diminution of the lower field of vision on both sides. The lower nasal field of the right eye is also considerably contracted. It must be emphasised, however, that the macula has been almost completely spared; it has been involved only to a slight degree at its upper border.

At post-mortem there was found a syphilitic endarteritis of both anterior choroidal arteries. The distribution of the latter to the posterior limb of the internal capsule and to the cerebral peduncle would be sufficient to account for the paresis and anaesthesia (I have confirmed the findings of Kolisko to that extent), but what is far more important as far as we are concerned was the finding of a clear-cut area of degeneration affecting the *lateral aspects of both lateral geniculate bodies.* Now, according to the work of Brouwer and Zeeman, the lateral portion of the lateral geniculate body corresponds with the projection of the lower quadrants of both retinae towards the same side, i.e. with the upper quadrants of both visual fields towards the opposite side. Since the upper half of each visual field has almost completely gone, we can regard the interference with vision as a bilateral superior homonymous quadrantic hemianopia, corresponding with the bilateral involvement of the lateral aspects of the lateral geniculate bodies; further, since the defect is more marked towards the left than the right, it is safe to assume that the right lateral geniculate has undergone a more extensive degeneration than the left. The arterial involvement was clearly unequal, because the paresis and anaesthesia are recorded as having been on the right side only.

As far as I am aware, this is the first recorded case of a visual defect associated with the anterior choroidal artery. In Kolisko's first case no interference with vision was found; but it must be emphasised that there is no record of any perimetric charting. Apparently, there was merely no complaint on the part of the patient of deficiency of sight. Here, then, are two cases of similar pathological import; one with the record of no visual defect, the other having both subjective and objective interference with sight.

These are the only two accounts I can find of undoubted anterior choroidal arterial interference. Henschen (6, 7, 8), it is true, has collected an enormous number of cases of visual lesions, but, although some of his clinical and pathological findings leave no doubt that the anterior choroidal artery was involved, in no case is there mention of an examination of the individual vessels, and so, for our purpose, his valuable collection is useless.

MATERIAL AND METHOD

In nearly every investigation of cerebral arterial supply the various arteries have been injected with a coloured mass, followed by the examination of transverse, horizontal and sagittal sections of the whole brain.

Duret, in his pioneer work, apparently combined injection of the vessels with the dissection of their surface distribution, but he did not follow the arteries through the brain substance for fear of rendering the structures through which they passed unrecognisable. He was content to cut sections through the whole brain and identify individual vessels by matching adjoining sections. The same technique was employed by Heubner, Kolisko and Beevor.

Aitken (9), in a series of beautiful illustrations, has demonstrated that arteries can be traced through the brain substance to their terminations without destroying the structures through which they have passed. In this investigation—dealing as it does with the blood supply of a comparatively superficial structure—we are not concerned with following our vessels any great distance into the brain itself. At the same time, as the field of enquiry was increased to include the complete distribution of the anterior choroidal artery (the results will be published later), it was found that Aitken's method could be employed with advantage, since it obviously is more exact than the former.

The dissections were performed upon twelve human hemispheres which had been preserved in formalin for varying periods, consequently it was impossible to inject them satisfactorily with coloured gelatine mass. In the case of the first six hemispheres, the dissection was made without injection; subsequently, it was found possible to inject the anterior choroidal artery quite successfully with indian ink by the aid of a syringe and a very fine hypodermic needle, the artery then being tied off with silk to prevent any reflux escape of the ink. This naturally rendered dissection much more simple, and the results were satisfactory in that they completely confirmed the findings of the first dissections and also threw some light upon the results of previous investigators. In particular, they explained the reason for Beevor's failure to inject the lateral geniculate body *via* the anterior choroidal artery in nineteen cases out of twenty-three. This I will discuss more fully later.

After the arteries had been dissected in their surface distribution, their terminal disposal within the geniculate body was studied. The block of brain containing the latter was cut in sections 1 mm. thick with a safety razor blade by hand. These sections were stained individually with alum-haematoxylin and eosin and cleared with oil of wintergreen. Examination with a binocular microscope by strong transmitted light displayed the end arteries in relation to the cell masses and fibre bundles.

As a corollary to the investigation of the human condition, the blood supply of the lateral geniculate body was studied in a limited, but representative, phylogenetic series. This series comprised six anthropoid, two lemur, four sheep, two Marsupial, two crocodile and two *Sphenodon* hemispheres.

The methods employed were the same as in the human: the vessels were first examined in their surface arrangement and the terminal distribution was subsequently ascertained by means of thick, cleared sections. In all cases, except that of the sheep, the thick sections were checked against ordinary thin sections stained for cells and so error was largely eliminated. In the case of the sheep, although no such sections were available, it is felt that there is very little chance of mistake, as the picture seen in the thick sections was quite clear. (These have since been checked against thin sections stained for cells and found to correspond accurately.) The *Sphenodon* brain was, naturally, too valuable to be dissected, so the arterial distribution was studied from the surface only. Fortunately, I had access to a series of transverse sections which served as a valuable guide.

THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY IN MAN

A. The anterior choroidal artery

I do not propose to discuss here the various modes of origin and distribution of this vessel. These have been fully described by previous workers and reference to the papers by Duret, Heubner, Henle (10), Kolisko, and others will suffice for the purposes of those who wish to follow the subject further; I shall go more fully into this matter in a subsequent publication. For the present, it is enough to state that I have observed every variation described by these investigators except that of complete absence of the anterior choroidal artery. In no case, in a series of some eighty hemispheres examined, was it impossible to find a vessel which had the origin, course and distribution of the anterior choroidal artery.

This vessel usually arises from the internal carotid artery at a varying level between the posterior communicating and middle cerebral arteries. From its origin it passes backwards and medially across the optic tract, when it runs along the medial aspect of the latter until it reaches the level of the anterior pole of the lateral geniculate body. Here it divides into a varying number of branches most of which turn rather abruptly laterally and, recrossing the optic tract, enter the inferior horn of the lateral ventricle to reach the antero-inferior part of the choroid plexus (fig. 1).

Throughout its course this artery gives origin to branches which are distributed to the structures close to which it runs. These have been described in some detail by previous workers, but, although my findings do not coincide in all respects with theirs, I shall not enter upon a minute description of the complete distribution of this artery at present; a brief account will not, however, be out of place.

The most striking of these branches are those which are said to enter the superficial surface of the optic tract for its supply in its course posteriorly. Aitken has pointed out that these vessels often do not perforate the optic tract, but "wrap themselves around either its medial or lateral aspect." Actually, the branches which perforate the optic tract are few and fairly large. They supply a few small twigs to the tract, but the main vessels pass dorsally into the base of the brain to reach the posterior limb of the internal capsule and the optic radiation. The branches which "wrap around" laterally are distributed to the base of the brain to reach the corpus striatum, and some pass laterally to the temporal pole, the uncus and the posterior part of the amygdaloid nucleus. Of those which run medially, some pass to the pes pedunculi and through the latter to the substantia nigra, some pierce the base of the brain while most of the remainder "wrap around" the medial aspect of

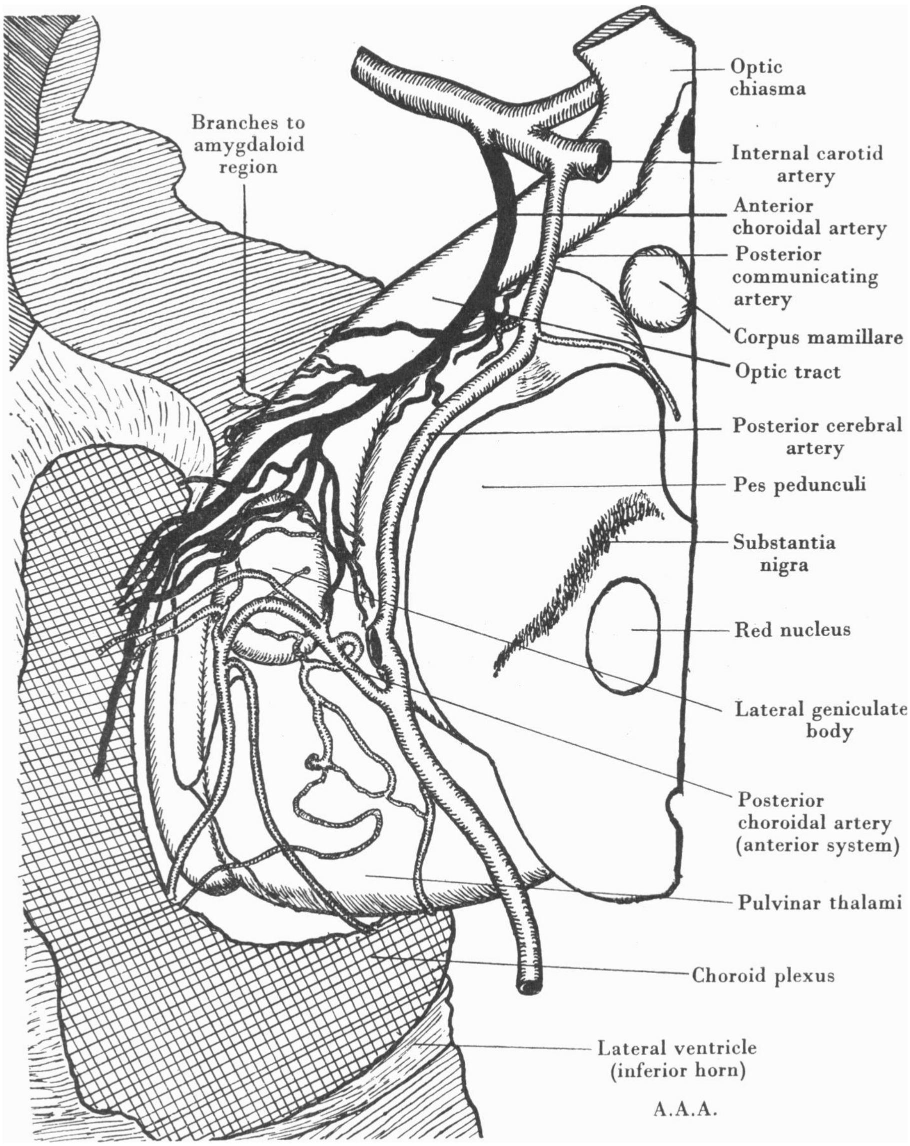

Fig. 1. Drawing of the general origin, course and distribution of the injected human anterior choroidal artery; note how the injection has missed some of the terminal branches of the artery.

the optic tract to enter its dorsal surface. It is these last which are the true arteries of supply to the tract. In addition to these vessels, there are rich anastomoses in the pia mater with branches of the middle cerebral, posterior communicating and posterior cerebral arteries.

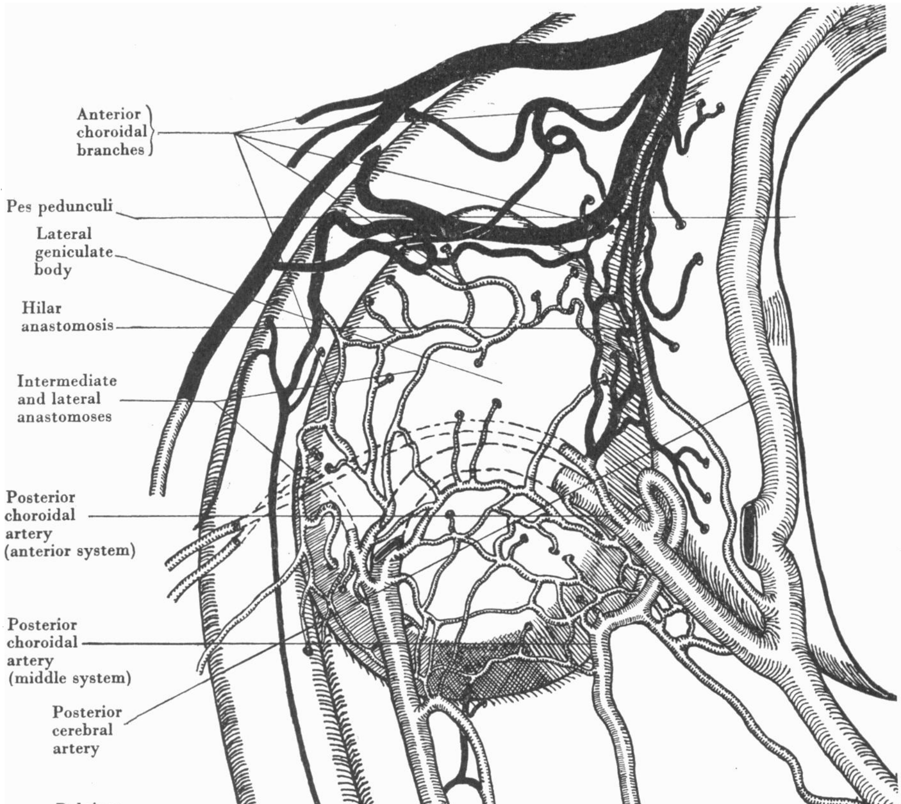

Fig. 2. The distribution of the anterior choroidal and other arteries over the surface of the lateral geniculate body; from the same specimen as fig. 1.

The terminal divisions of the anterior choroidal artery vary greatly in size and number in different specimens. Often a large branch turns medially to join the anastomosis on the crus, whilst one vessel very constantly enters the stria terminalis in which it runs posteriorly for some distance. Apart, however, from the branches to the lateral geniculate body, the majority of the remainder pass to the choroid plexus (fig. 2).

With regard to the part played by the anterior choroidal artery in the vascularisation of the lateral geniculate body, a very constant arrangement was observed which held, with minor variations, for every dissection. Two, three or more medium-sized branches arise from the terminal divisions of this artery and take part in the anastomoses subsequently to be described (fig. 2). Usually two or three of these arise medially and pass posteriorly in the vallecula which lies medial to the geniculate eminence. (This eminence, it will be remembered, corresponds only with the most lateral part or tail of the geniculate body; the vallecula is the hilum, and a portion of the ganglion lies more medially still, against the crus, forming a medial elevation.) These medial vessels, then, enter into a very rich anastomosis with branches from the posterior cerebral and posterior choroidal arteries.

As the anterior choroidal divisions pass laterally anterior to the geniculate body a further series of small vessels runs posteriorly from them and back over the geniculate eminence to join the intermediate and lateral anastomoses. These anterior branches may all arise separately, or wholly, or in part, from a common stem. Whatever their mode of origin, however, they invariably proceed to these final anastomoses. In addition to the above, one or more large vessels take origin from the anterior choroidal divisions after they have passed some way back in the choroid plexus. These arteries leave the lateral ventricle and run medially to reach the lateral aspect of the lateral geniculate body.

B. Posterior choroidal arteries

Duret, in his description of the choroidal arteries, mentions a postero-lateral and a postero-median choroidal artery. He states that the anterior choroidal artery supplies the antero-inferior part of the choroid plexus, and that the postero-lateral "completes the vascularisation of the choroid plexus." The postero-median artery is described by him as passing directly backwards on the side of the pineal body to which it gives some twigs. It soon divides into two branches which supply the choroidal membrane and plexus of the third ventricle. Charpy describes only one posterior choroidal artery (11), and states that, "Cette artère est relativement atrophiée"; he also mentions a median choroidal artery which may arise from the posterior cerebral artery or from the superior cerebellar and which passes to the choroid plexus of the third ventricle. Presumably, it corresponds with Duret's postero-median artery.

Leaving out of account the postero-median, or median, choroidal artery as not coming within the sphere of the present enquiry, I find that I cannot support the statement that the posterior choroidal artery is "relatively atrophied"; on the contrary, I can usually distinguish three, and sometimes as many as five, large vessels which pass from the posterior cerebral artery to reach the choroid plexus. These, then, must correspond to Duret's single postero-lateral choroidal artery. In addition, the posterior choroidal vessels show a steady increase in number and complexity as we ascend the phylogenetic scale. Careful study of these vessels forces me to the conclusion that they are the persisting representatives of a large number of transverse arteries which had been interconnected by several longitudinal anastomoses. The remaining vessels are the surviving portions of some of the stem arteries and parts of the original network which have been picked out from the many intermediate paths available. The varying modes of origin, and the very diverse courses of distribution pursued by these vessels can be an expression of no other circumstance.

The functional end arteries have remained constant throughout; it is only the stem arteries and the vessels of distribution which have varied. Indeed, Duret makes this striking observation (concerning cerebral arteries in general): "C'est là du reste, une loi générale pour les artères du cerveau: leur origine est souvent très-variable, mais leur champ de vascularisation est constant" (p. 81). This principle is a remarkable anticipation of the work of Stopford (12) and Shellshear (13-18), but was never pursued further by Duret. Shellshear in particular, as the result of his numerous investigations of the blood supply of the cerebral cortex of a large number of animals, and especially of Man, has always insisted upon the functional constancy of vascularisation of the brain, and was the first to place this hypothesis upon a firm anatomical basis (13, 14, 15, 16, 17, 18). In the same relation it is interesting to note that Guyot, in 1825 (19), made a somewhat similar statement.

In all these dissections it was possible to distinguish three main systems of posterior choroidal arteries to which I shall refer as the anterior, middle and posterior systems. The anterior and middle systems alone are concerned in the blood supply of the lateral geniculate body; I was totally unable to discover any branches proceeding from the posterior system to this ganglion.

The anterior system takes origin from the posterior cerebral artery at a variable point, usually anterior to the sulcus lateralis of the peduncle (fig. 2). Characteristically, it is composed of one fairly large vessel supplemented by one or two much smaller ones which may arise apart, but often take origin in common with the main vessel. These pass forwards or backwards until they reach approximately the level of the centre of the geniculate body when they turn laterally and, crossing the latter, enter the inferior horn of the lateral ventricle, posterior to the anterior choroidal divisions, and reach the choroid plexus. The largest of these vessels is fairly constant, but the smaller ones vary considerably. In the choroid plexus they all join in the general anastomosis, but we need not pursue their course further at present.

The anterior system plays an important part in the formation of the series of anastomoses over the surface of the lateral geniculate body. Close to its origin it gives a large number of small branches to the rich medial anastomosis, while, as it proceeds laterally, it similarly reinforces the intermediate and lateral anastomoses. These branches may arise in part or solely from a common stem, but they pass constantly to their destinations. Some of the smaller twigs pass directly into the substance of the geniculate body, while frequently a further branch arises from the choroidal divisions and pursues a recurrent course out of the ventricle to reach the lateral anastomosis posteriorly.

The middle system usually consists of a single, fairly large vessel arising from the posterior cerebral artery just posterior to the anterior system, but it may take origin in common with it. However it arises, this vessel runs forwards or backwards until it reaches a level just posterior to the posterior pole of the geniculate body, when it turns laterally to pass behind the latter. After a variable lateral course, the artery bends posteriorly in a wide curve and, passing dorsally around the thalamus, enters the central part of the choroid plexus.

In its passage posterior to the geniculate body, the artery generally divides into a number of branches which subserve its terminal distribution in the choroid plexus. These terminal branches appear to vary considerably, but in actual fact, if a number of dissections be compared, it is found that the mean of their combined courses is fairly constant. In particular, either the main trunk or one of its branches almost invariably goes out of its way to pass anteriorly, close to the posterior pole of the geniculate body, before sweeping around posteriorly and dorsally to reach the choroid plexus.

The reason for describing what is apparently a single artery as a system is now clear, for the distribution of its terminals can only be regarded as the expression of an originally large series of vessels passing from the posterior cerebral artery to the central part of the choroid plexus, and the longitudinal anastomoses between them. What remains is the survivor of portions of this network, most of which has disappeared.

The branches from this system are numerous, but we need only discuss those to the geniculate body. Briefly, they arise from the main trunk and its branches as these pass laterally. They are especially rich medially where they join the medial anastomosis; more laterally they are less numerous as they pass forward to complete the intermediate and lateral anastomoses. These twigs may arise individually or in bunches, and a large number enter the substance of the geniculate body directly.

The posterior system of posterior choroidal arteries comprises, usually, one or more fairly large vessels which arise from the posterior cerebral artery and pass to the choroid plexus. These vessels also are very variable in their mode of origin and in the course they pursue; the remarks made concerning the middle system apply equally well here and need not be repeated. Briefly, they pass dorsally around the thalamus close to the mid-line to reach the more dorsal and anterior parts of the choroid plexus of the lateral ventricle. They take no part in the blood supply of the lateral geniculate body and require no further description here.

C. The arterial anastomoses over the surface of the lateral geniculate body

The proportion of vascular supply to the geniculate body undertaken by any one of the systems just described (anterior choroidal, anterior and middle systems of posterior choroidal) is very hard to assess accurately on account of the intricate network of vessels over its surface. One cannot doubt that such rich vascularisation is evidence of the great functional importance of this ganglion, and I hope to show that the distribution of these arteries bears a constant relation to that functional differentiation which we already know to exist from the researches of Brouwer and Zeeman, Minkowski and Le Gros Clark.

The vascular network can be resolved into three main longitudinal series of anastomoses which have been referred to as the medial, intermediate and lateral anastomoses. Further, an anterior, middle and posterior series of transverse anastomoses can be described, but, as these have neither the phylogenetic nor the functional significance of the former, they can safely be neglected (fig. 2).

For the sake of simplicity, we can regard the anterior and middle systems of posterior choroidal arteries as being only posterior cerebral, for this differentiation has no importance as far as the lateral geniculate body is concerned. Of the three, the medial anastomosis is by far the richest. It receives important support from the anterior choroidal artery, but at least two-thirds of its blood comes from posterior cerebral branches. This vascular network ramifies in the vallecula or hilum and gives a very rich supply to this region, both medially and laterally. The intermediate and lateral chains of anastomosis are sometimes hard to distinguish, and they dwindle away as we pass laterally over the eminence. In this movement, laterally, we find that the anterior choroidal contributions become increasingly more substantial, while those from the posterior cerebral artery correspondingly diminish. So, when we reach the lateral border, we find that practically the whole of the blood is supplied by the anterior choroidal artery (taking into account, especially, the strong reinforcements from the choroid plexus).

Now it is possible to say that the anterior choroidal artery is distributed to the anterior, but especially the lateral parts of the ganglion, while the posterior cerebral artery reaches the posterior, but especially the medial regions. The region of the hilum has by far the richest blood supply, which comes from both sources, but mainly from the posterior cerebral artery.

D. Distribution of the arteries within the lateral geniculate body

In the thick clarified sections through the geniculate body (fig. 3 A and B) the terminal distribution of the end arteries is easy to follow. These vessels pass into the ganglion from the surface, but while the majority end within the nucleus, there are some which pass right through and then accompany the fibres of the optic radiation. The more detailed drawing of the vessels shows that the terminal twigs all end accurately within a particular cell lamina. Each cell lamina can be regarded as a distinct nucleus having its own discrete blood supply. Further, it can be seen that a vessel in its course through the geniculate body gives branches which are distributed to corresponding areas of adjoining cell laminae from the ventral to the dorsal border. In addition, in association with the lateral eversion of the human geniculate body, a distinct hilum has been produced, and from this hilum the vessels tend to radiate dorsally, medially and laterally to reach their final objectives; there are, however, a few arteries which pass into the lateral eminence almost at right angles to the surface to vascularise the lateral part of the ganglion.

We have already seen that the medial anastomosis lies within and on the lips of the hilum and, in accord with the much greater number of vessels in this region, we find that the number of terminal twigs distributed to this intermediate quadrant of the geniculate body is greater than to the more medial and lateral segments. Further, this intermediate part is supplied from two sources, from the anterior choroidal artery and from the posterior cerebral artery, although the latter contributes the greater support. The tail, or eminence, receives the major portion of its blood from the anterior choroidal artery and the medial part more from the posterior cerebral artery.

Brouwer and Zeeman (20–22) have shown that this intermediate quadrant is almost entirely macular in its projection, while the medial and lateral portions are predominantly non-macular; the upper part of the retina is projected medially and the lower half laterally. Thus, it is obvious that the macular quadrant, which is functionally the most important, has by far the greatest blood supply and, in addition, draws its nourishment from two sources. While this double blood supply has probably been evolved in accordance with the greater functional activity of the part, it certainly must compensate to a large extent for interference with either of its sources, but especially with the anterior choroidal artery, thus tending to spare the macular projection.

Reverting to Dr Ivy McKenzie's case we can now see why, although the anterior choroidal artery was affected, the macular interference was at a minimum, while the non-macular field was more extensively involved. Fig. 3 C is a drawing taken from a slide of one of the geniculate bodies in the case in question. Here it will be seen that the area of degeneration of the cells is strictly limited to the lateral part of the ganglion in accordance with both the vascular lesion and the perimetric recording, but the macular projection quadrant is scarcely encroached upon.

It is possible to go further than this, however, for there is evidence to show that the distribution of the terminal vessels is even more precise than has so far been described.

Minkowski (23) and Le Gros Clark (24) have both shown that corresponding retinal areas are projected in alternate cell laminae of the two geniculate bodies, e.g. crossed fibres end in what Le Gros Clark calls 1 *a*, 2 *b* and 3 *b*, while uncrossed fibres terminate in the remaining laminae 1 *b*, 2 *a* and 3 *a*, and it follows from the work of Brouwer and Zeeman that adjoining parts of

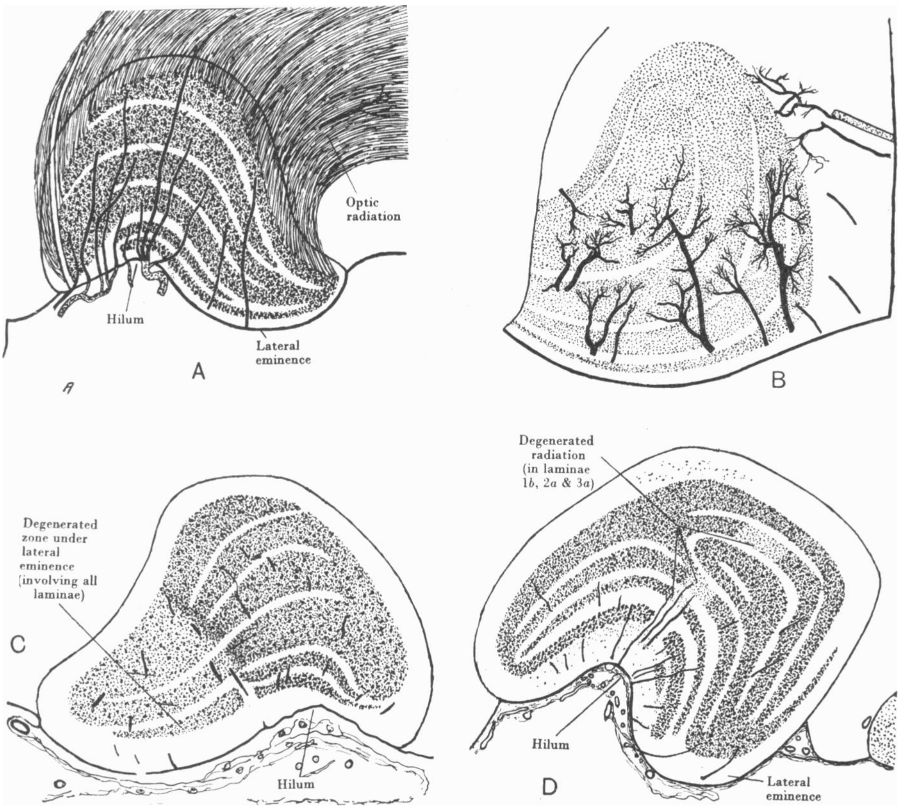

Fig. 3. *A*. Thick section of the human lateral geniculate body; note the rich vascular supply to the hilar region and the poorer supply medially and laterally.
B. Thick section of a human lateral geniculate body illustrating the termination of the end arteries in the cell laminae.
C. Right lateral geniculate body from slide kindly lent by Dr Mackenzie showing atrophy of the cells in the lateral part consequent upon interference with the anterior choroidal artery.
D. Section of the lateral geniculate body of a *Macaque*. This is from an animal which was operated upon by Mr Penman of St Thomas's Hospital, a lesion being inflicted in the temporal side of the macula of the homolateral eye. Kindly lent by Professor Le Gros Clark.

neighbouring cell laminae are related to corresponding areas of both retinae. Thus, if a small area of laminae 1 *a*, 2 *b* and 3 *b* be related to the nasal field of the opposite eye, then the intervening parts of laminae 1 *b*, 2 *a* and 3 *a* correspond to the temporal field of the homolateral eye.

Fig. 3 D represents a drawing made from a slide of the geniculate body of an ape. In this animal a lesion had been experimentally produced involving the temporal side of the macula of the homolateral eye. The circumscribed areas of degeneration in laminae 1 *b*, 2 *a* and 3 *a* are clearly depicted. We can be fairly certain that the intervening sections of the remaining laminae are related just as closely to the nasal side of the opposite macula. It is important to note how the vessels radiate from the hilum, and how some of them are passing right through this fan-shaped area of degeneration. We have already seen that as a vessel passes through the cell laminae it radiates from the hilum in the same way as this degenerated area, and as the whole macular projection zone does in Brouwer's diagrams. Further, we have seen that in its passage through the geniculate body each individual artery gives off twigs to the adjoining parts of neighbouring cell laminae as it passes through them. There can be very little doubt, then, that *each individual end artery is as closely related to each individual retinal projection area within the lateral geniculate body as are the very cells which subserve this projection.* In this relation, it is of interest to note that the same arteries which nourish these cells frequently accompany their axones for some distance into the optic radiation.

To summarise the condition in Man:

(1) The anterior choroidal artery plays a large and constant part in the blood supply of the lateral geniculate body.

(2) The anterior choroidal artery is related to the lateral aspect of this ganglion, while the posterior cerebral branches are distributed more medially and posteriorly.

(3) The area of greatest functional importance—the macular projection area—has by far the richest blood supply, and this supply is drawn from the double source of the anterior choroidal and the posterior cerebral arteries.

(4) There is evidence to show that the end arteries within the lateral geniculate body are distributed in close relationship with the projection of the visual fields in this ganglion.

The discrepancy of Kolisko's first case is now apparent. The patient was a sick old man with hemiplegia who died of pneumonia a fortnight later. It is unlikely that such a patient would complain of a visual defect which was related only to the upper quadrant of both fields of vision towards the opposite side and in which the macula was little involved if at all. Such a visual defect may have existed, but was unobserved in the absence of any perimetric investigation.

We have seen that the anastomoses over the geniculate body are very rich. It is clear that these are sufficient to ensure injection of the ganglion *via* the posterior cerebral artery. This explanation is the only one which can be adduced in explanation of the failure of previous workers to inject this body. There is no doubt that the anterior choroidal artery plays a very constant part in the blood supply of the lateral geniculate body.

THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY IN APES

The injected or uninjected vessels were dissected in the six hemispheres of three apes. The anterior choroidal artery was examined in eighteen hemispheres which included brains from *Lagothrix*, *Papio*, *Cercopithecus* and *Macacus*. In all of these cases the artery was constantly present, well developed and easily demonstrated. There were minor variations which corresponded with the human condition.

A. The anterior choroidal artery

This vessel, in its passage from the internal carotid artery to the anterior pole of the lateral geniculate body, is so similar to the human that there is no necessity to repeat the description. When it reaches the geniculate body, however, the condition, although comparable, does not conform exactly to our previous description (fig. 4). In the human it was seen that the main course of the anterior choroidal artery was into the choroid plexus in the lateral ventricle, while the branches which passed posteriorly to take part in the medial, intermediate and lateral anastomoses were of minor importance. In the ape we find that the branches to the geniculate body are much larger, while the choroidal divisions have become relatively reduced in size. Further, it is the large terminals to the geniculate body which now course posteriorly over the surface of the latter and replace the intermediate and lateral anastomoses. The branches which enter into the medial or hilar anastomosis are likewise increased in importance.

B. Posterior choroidal arteries

The condition of the posterior choroidal arteries in the ape conforms fairly closely to Duret's description of a postero-lateral and a postero-median artery for Man. The former arises from the posterior cerebral artery in the same position as did our anterior system in Man, and it runs across the lateral geniculate body to reach the lateral ventricle. Before this occurs, it enters into such a free anastomosis with the anterior choroidal artery that the two vessels lose their individuality, and it is impossible to distinguish them with certainty.

The postero-median artery follows the same plan of origin and distribution as in Man, but I have never seen this vessel arise from the superior cerebellar artery as described by Charpy. Between the postero-lateral and postero-median arteries are many small vessels which run from the posterior cerebral artery to the choroid plexus. These are certainly the predecessors of the middle and posterior systems in Man, but they have not attained the human degree of development because the functional demands made upon them are not such as to require a greater volume of blood than they already supply. Of all these, the only artery concerned with the lateral geniculate body to any extent is the postero-lateral. This, as we have seen, crosses the geniculate body and usually joins the anterior choroidal artery by a free anastomosis. Some branches from the posterior cerebral artery, as in Man, pass directly to the medial anastomosis.

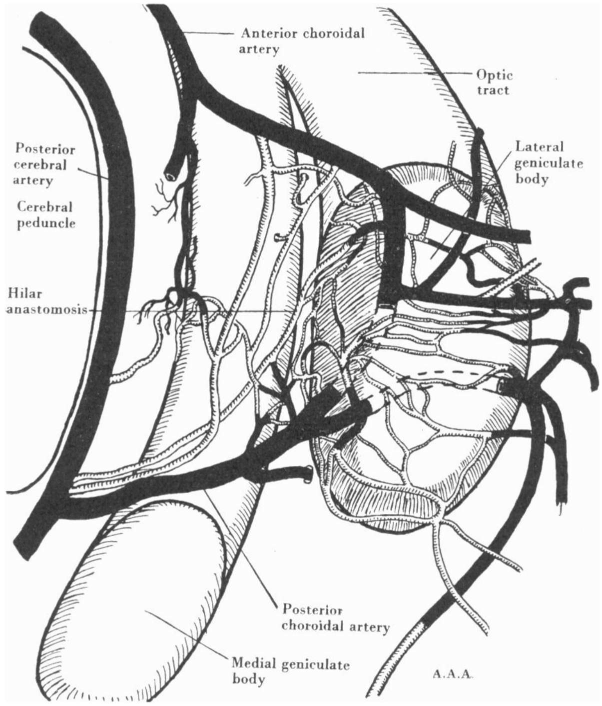

Fig. 4. Distribution of the arteries over the lateral geniculate body of a Guinea Baboon (*Papio papio*); the injection has flowed freely into the posterior choroidal artery.

C. Anastomoses over the surface of the lateral geniculate body

These can be dismissed with a short description. The medial anastomosis is again very rich and is probably supplied equally from the anterior choroidal and posterior cerebral arteries. The intermediate and lateral anastomoses are replaced by some of the main terminal divisions of the anterior choroidal artery which, in place of the small vessels of communication of the human condition, join the posterior choroidal vessel by a very free channel.

D. Distribution of the arteries within the lateral geniculate body

The condition here is so similar to the human that little further description is required. The end arteries pass into this ganglion chiefly from the hilum, but, in accordance with the greater degree of eversion of the geniculate body in the apes, the vessels fan out from this region much more markedly than in Man. The end arteries also terminate just as accurately in the cell laminae and are quite as certainly related to the retinal projection areas.

To summarise the condition in apes:

(1) The anterior choroidal artery supplies a much greater proportion of the lateral geniculate body than in Man.

(2) It is still closely related to the anterior, and especially the lateral aspects, and plays a much greater part in the vascularisation of the hilar, or macular, area. The posterior cerebral branches are here relegated to a more subordinate position.

(3) The distribution of the end arteries within the body is comparable with the human condition, and is related to the retinal projection areas. The slight variation is to be attributed to the greater degree of eversion of the anthropoid geniculate body.

(4) The terminal branches of the anterior choroidal artery, as in Man, nearly all join branches of the posterior cerebral artery, but the anastomosis is much more free.

THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY IN THE LEMUR

The condition was examined on both hemispheres of the brain of a *Lemur variegatus*. Although the arrangement of the arteries was, in the main, the same as in the higher Primates, the variations found called for the investigation of the condition in a larger series than I have at my command.

The lateral geniculate body of the lemur presents an anomalous condition which is not directly comparable with the state of affairs in higher animals. This has been investigated by Woollard (25, 26), Pines (27) and Le Gros Clark (28) and reference to these authors will suffice to define the present state of our knowledge.

It already appears from this single lemur brain that the arteries to the geniculate body are as far removed from the general line of Primate evolution as is the lemur itself. It is felt that the condition of the arteries is closely correlated with the aberrant evolution of the geniculate body, but it has been decided to defer their description until more exact information is available.

THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY IN THE SHEEP

The state of affairs was examined in four hemispheres and was found to be constant in all.

A. The anterior choroidal artery

This vessel was constantly present and of sufficient size to permit of its injection with some difficulty. It arises in its usual place from the internal carotid artery and passes posteriorly and dorsally along the optic tract. In its course posteriorly (fig. 5), the vessel lies first at the infero-posterior border of the tract and then gradually crosses the latter until it lies at its centre at the anterior pole of the diencephalon (which here corresponds with the anterior pole of the lateral geniculate body). Thence it passes obliquely across the latter until it reaches the antero-dorsal pole, where it turns medially and joins the posterior cerebral artery.

Throughout its course its branches are distributed as in Man, to the amygdaloid region, the optic tract, the choroid plexus and the pes pedunculi. In its oblique passage across the geniculate body it gives many branches which pass into the latter and into the diencephalon, and many others which anastomose with similar branches from the posterior cerebral artery. It will be noticed that it is the main trunk of the anterior choroidal artery which passes across the diencephalon to anastomose finally with the posterior cerebral artery, while the actual choroidal arteries are, even more than in the ape, of subsidiary importance.

B. Posterior cerebral artery

It is difficult to speak of posterior choroidal arteries in the sheep because they play very little part in the supply of the geniculate body. While a few small branches cross the diencephalon to reach the plexus of the lateral ventricle anteriorly, the major posterior choroidal contribution lies much more dorsally, out of our immediate field of enquiry.

The posterior cerebral artery arises from the junction of the posterior communicating and basilar arteries and runs obliquely dorsally across the pes to reach the groove between the medial and lateral geniculate bodies. Thence it again turns more obliquely and passes across the postero-superior angle of the diencephalon and so around the dorsal aspect of the latter to supply the choroid plexus and the posterior part of the cerebral hemisphere and to receive the termination of the anterior choroidal artery.

In its course it supplies branches to the pes, the medial and lateral geniculate bodies, the superior colliculus, and the diencephalon. In addition, there are several small branches for anastomosis with branches of the anterior choroidal artery.

C. Anastomoses over the surface of the lateral geniculate body

As will be seen from the illustration (fig. 5), these are by no means as complicated or as numerous as in the apes and Man. They are merely a series of small vessels which pass from the posterior cerebral artery to the anterior choroidal. The latter also has channels of communication with the middle cerebral and posterior communicating vessels.

D. The distribution of the arteries within the lateral geniculate body

The lateral geniculate body of the sub-Primates is formed of two distinct nuclei, dorsal and ventral. The latter is the more primitive, is developed from the subthalamus and is connected mainly with the tectum (Kappers (30), Le Gros Clark (29)). The dorsal nucleus is of later development, has evolved from the ventral nucleus of the thalamus proper and, in Primates, sends the

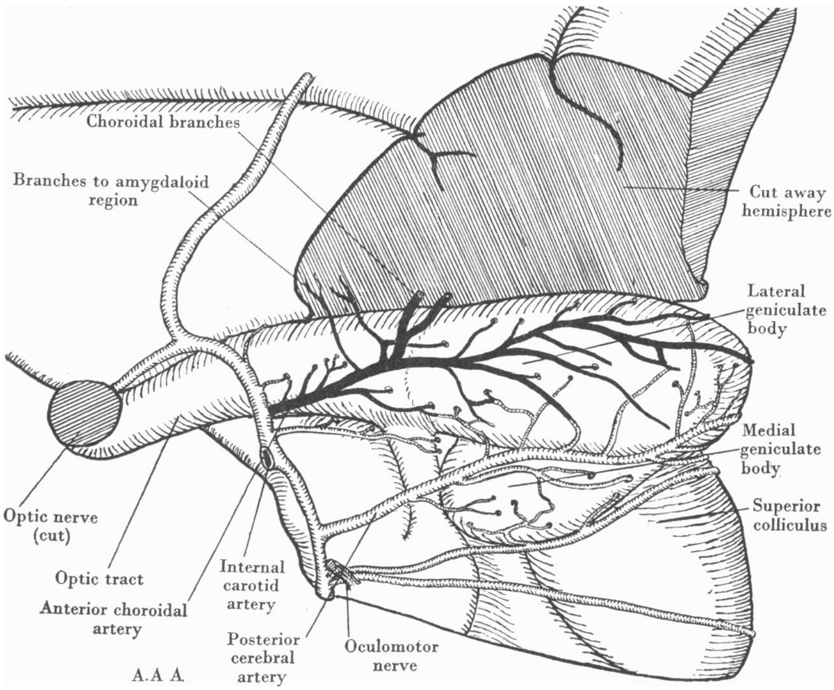

Fig. 5. Distribution of the arteries in the *sheep*. The anterior choroidal artery is injected.

majority of its efferent fibres to the area striata of the cerebral cortex. It is from the dorsal nucleus of lower animals that the complicated lateral geniculate body of the Primates has evolved, while the ventral nucleus is, in them, probably represented by the corpus pregeniculatum. Both dorsal and ventral nuclei are well developed in the sheep, but, as the details of their intimate blood supply are the same as in the Marsupial, I shall defer the discussion of these vessels until the condition in the latter has been described; the same description will serve for both.

THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY IN THE MARSUPIAL

The condition of the vessels was investigated in both hemispheres of a tree-kangaroo (*Dendrolagus*) and was found to be the same in both. This was checked by a series of *Dasyurus* sections stained for cells.

A. The anterior choroidal artery

This vessel was easily found and could be injected with some difficulty. It arises from the internal carotid artery as usual and passes dorsally along the centre of the optic tract. At the anterior pole of the diencephalon the vessel turns cranially and continues its dorsal course along the most anterior part of the diencephalon. Then it turns medially and finally anastomoses with the posterior cerebral artery (fig. 6).

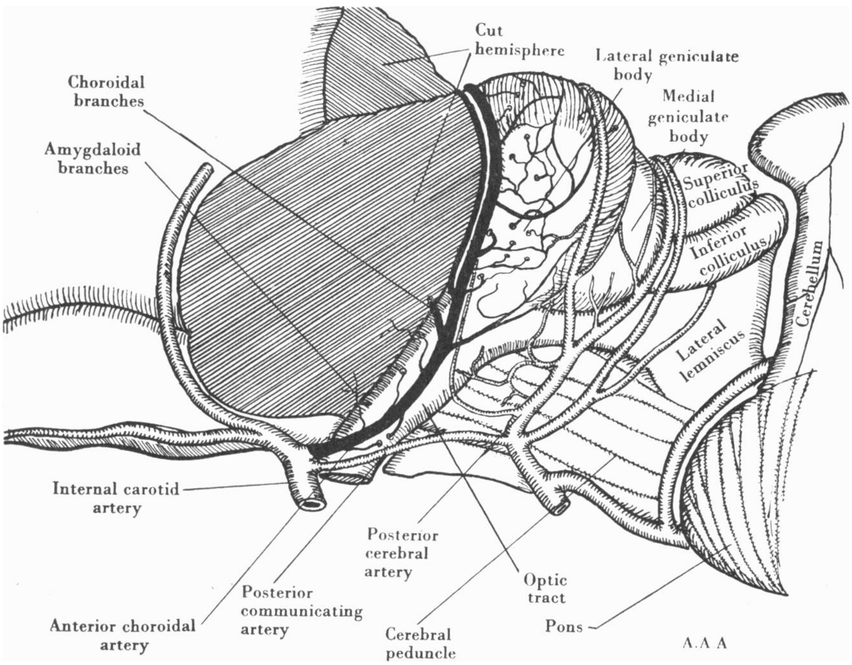

Fig. 6. Distribution of the arteries in the Marsupial (*Dendrolagus*), anterior choroidal artery injected.

The branches given off are exactly comparable with those observed in the sheep, i.e. to the amygdaloid region, the optic tract, the choroid plexus and the diencephalon whose most lateral border is here almost entirely overlaid by the lateral geniculate body. In addition, there are branches which anastomose with the middle cerebral, posterior communicating and posterior cerebral arteries, the last over the lateral geniculate body. It will be seen that the main vessel is that which passes dorsally over the geniculate body to anastomose with the posterior cerebral artery; the actual branches to the choroid plexus of the lateral ventricle are, in the Marsupial, very minute.

B. Posterior cerebral artery

The posterior cerebral artery seems to acquire most of its blood from the basilar in this animal, and the posterior communicating artery is only a small vessel. This vessel passes dorsally across the pes and medial geniculate body to reach the caudal border of the lateral geniculate body. Here it at once turns cranially and continues its course dorsally over the centre of the geniculate body. It gives the usual branches to the pes, tectum, medial and lateral geniculate bodies. Also there are anastomotic twigs to the anterior choroidal artery over the geniculate body and, finally, the latter artery joins the posterior cerebral.

C. Anastomoses over the surface of the lateral geniculate body

These are as simple as those of the sheep and require no detailed description.

D. The distribution of the arteries within the lateral geniculate body

According to Tsai (31), the lateral geniculate body of the Marsupial is very well developed and consists of separate dorsal and ventral nuclei. I have been able to check these observations both in the thick sections and in a series of sections stained for cells.

Fig. 7 represents a series of drawings of thick sections through the lateral geniculate body with the dorsal and ventral nuclei represented in outline only. These sections show the relation of the geniculate body to the optic tract, and represent successively posterior levels passing from A to D. The anterior choroidal artery is drawn in black, and it can be seen that as we pass posteriorly and dorsally so the anterior choroidal artery ascends in the sections just as we observed from the surface dissection. At the same time the dorsal nucleus migrates in the same direction, and the close relation between the artery and the dorsal nucleus is very striking as we pass posteriorly; the artery maintains a faithful affinity to the course of its field of supply. The terminal twigs of the anterior choroidal artery pass into the dorsal nucleus but were never observed to reach the ventral. In fact, we may say that the anterior choroidal artery is the chief source of supply for the dorsal nucleus. Its branches, too, can be seen passing through the dorsal nucleus to accompany the optic radiation as in higher animals.

The branches of the posterior cerebral artery are just as closely related to the ventral nucleus, and the artery seems to pass upwards in the sections in association with the increase in size of the ventral nucleus. There is however one striking difference. In all sections one or two branches of the posterior cerebral artery pass some distance dorsally in the optic tract until they reach the level of the interval between the two nuclei; then, passing medially in this interval, these branches give off twigs which reach, not only the dorsal aspect of the ventral nucleus, but also *the ventral part of the dorsal nucleus.*

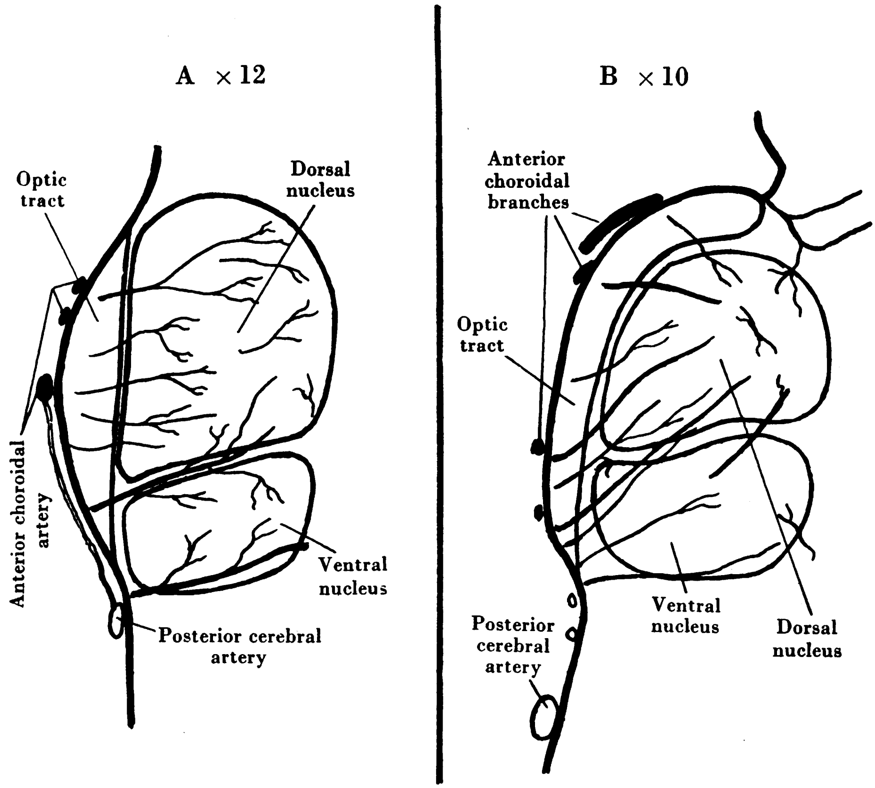

Fig. 7 (*A*, *B*).

Fig. 7. Terminal distribution of the end arteries within the lateral geniculate body of the Marsupial. *A—D*, sections running posteriorly, showing the relation of the anterior choroidal artery to the dorsal nucleus and the posterior cerebral artery to the ventral; note branches of the latter passing to the dorsal nucleus.

The ventral portion of the dorsal nucleus thus receives a double supply; partly from the anterior choroidal artery and partly from the posterior cerebral artery.

Now we know that the dorsal nucleus of the lower Mammals becomes the main nucleus of the Primates, and we also know that this latter ganglion has become everted during its evolution so that its more dorsal part comes to lie laterally, and the ventral part lies medially. In between is the hilum which represents the axis of rotation.

In Man and the apes, we saw that the posterior cerebral branches supplied the medial aspect of the geniculate body and the anterior choroidal the lateral aspect, while the hilum received its supply from both arteries. The homology is complete, for the arterial distribution is the same, with the ventral part of

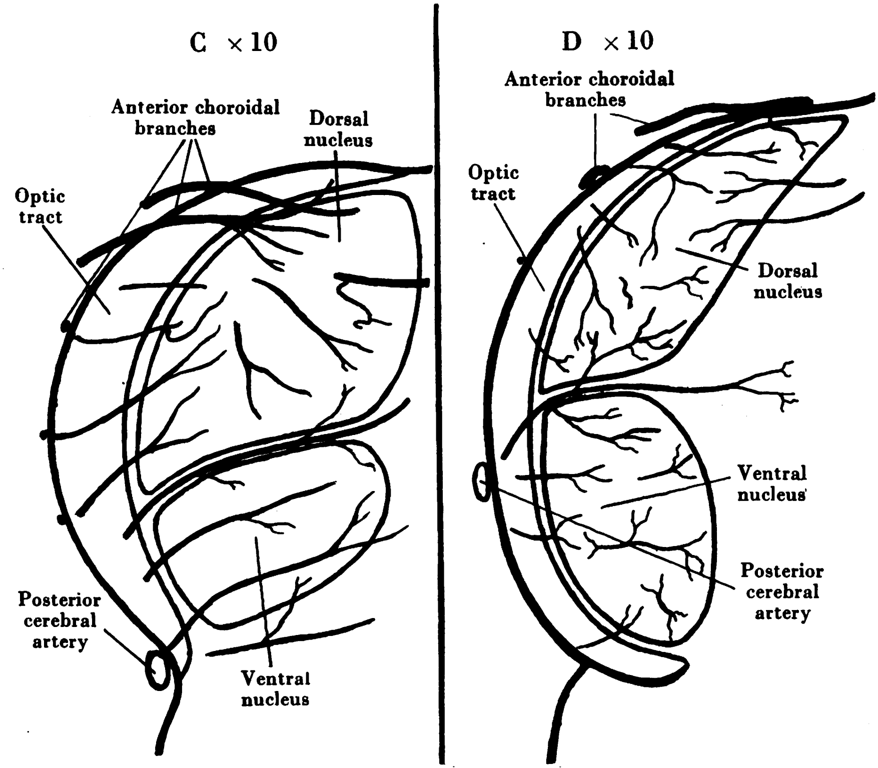

Fig. 7 (*C*, *D*).

the dorsal nucleus representing the medial border of the Primate geniculate body and supplied by the posterior cerebral artery; the next most ventral part is supplied by both arteries and represents the hilum, or axis of rotation, while the most dorsal part of the dorsal nucleus represents the lateral aspect and receives its supply almost entirely from the anterior choroidal artery.

The arrangement of the vascular supply in the sheep closely resembles that of the Marsupial.

To summarise the findings in the *Eutheria* and the *Metatheria*:

(1) The lateral geniculate body is divided into separate dorsal and ventral nuclei each of which has its own specific blood supply: the dorsal nucleus

receives most of its blood from the anterior choroidal artery, but its ventral part is vascularised by the posterior cerebral artery as well; the ventral nucleus is supplied solely by the posterior cerebral artery.

(2) The blood vessels are distributed in an exactly comparable manner to those in the Primates: the part of the dorsal nucleus which is supplied only by the anterior choroidal artery corresponds developmentally with the lateral part of the Primate geniculate body which also takes its blood from the anterior choroidal artery; the intermediate section, corresponding with the hilum, is vascularised by both vessels, and the most ventral part of the dorsal nucleus, which is the predecessor of the medial portion of the Primate geniculate body, is supplied by the posterior cerebral artery.

(3) The anterior choroidal artery is precisely comparable with its homologue in higher Mammals in the origin from the internal carotid artery, the course along the optic tract, the distribution to the tract, the geniculate body, the amygdaloid nucleus and pes, and in the termination in the posterior cerebral artery. The main difference is that, as we descend the phylogenetic scale, the vessel is progressively of less importance as a choroidal artery, because the choroidal branches become smaller; while the main portion of the vessel becomes more and more that channel which runs posteriorly over the lateral geniculate body to end in a free anastomosis with the posterior cerebral artery.

THE BLOOD SUPPLY OF THE LATERAL GENICULATE BODY IN THE CROCODILE

This was examined in both hemispheres of the brain of an Indian gharial. It was impossible to inject any individual anterior choroidal vessel, so the whole arterial system was injected with indian ink through the basilar and internal carotid arteries.

A. The anterior choroidal artery

For convenience of description, it will be useful, in the case of the crocodile and *Sphenodon*, to regard the internal carotid artery as dividing into cranial and caudal branches, as done by Hofmann (31*a*) and de Vriese (32, 33). The cranial branch is the anteriorly directed division of the internal carotid which gives rise to the middle cerebral artery, and is continued as the anterior cerebral artery. The caudal branch is the posterior cerebral artery of higher animals.

When we examine fig. 8, we can see that there is a system of tiny vessels which arise from the cranial artery, run posteriorly on the optic tract and terminate in the caudal artery. Further, this system supplies branches to the optic tract, the amygdaloid region, to the diencephalon (whose most lateral aspect is occupied by the lateral geniculate body) and also anastomotic twigs to the middle cerebral and caudal arteries. This network, then, is certainly the predecessor of the anterior choroidal artery, and shows a fair amount of variation in the crocodile. On the right side of the brain it is represented by a rich network of tiny vessels, but, on the left side (that illustrated), it is more definitely a discrete artery. It may be objected that this vessel has no choroidal branches, but it must be remembered that in reptiles the lateral ventricle has no inferior horn—the choroid fissure is limited to the region of the foramen of Monro—and the choroidal branches of the caudal artery pass into this region and suffice for its requirements.

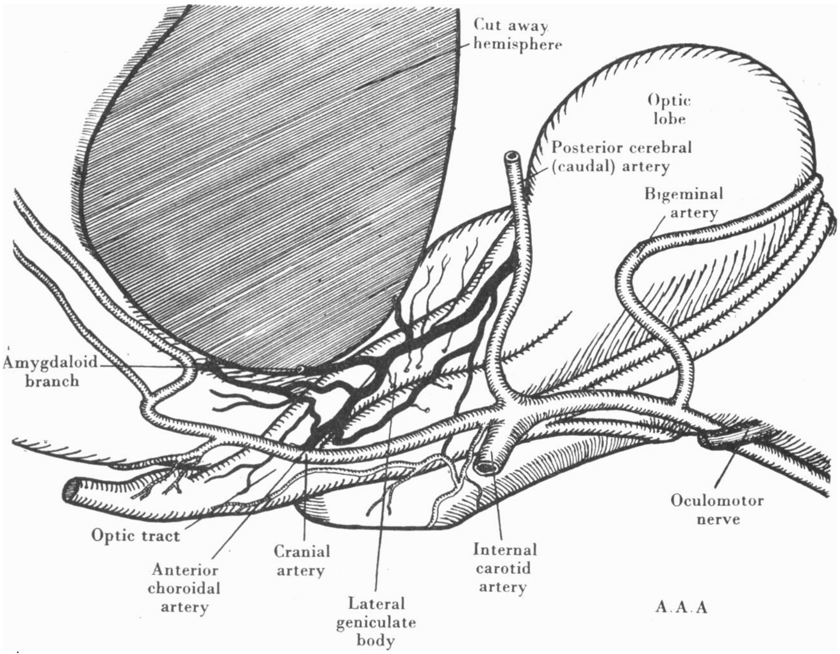

Fig. 8. Distribution of the arteries in the Indian *gharial*, the anterior choroidal artery is represented in black, but was not separately injected.

This condition will become clearer after we have examined the posterior cerebral artery in the crocodile and the arrangement in *Sphenodon*. In the meantime, it can be noted that this vessel satisfies all the criteria for homology with the anterior choroidal artery except that it has no connection with the choroid plexus.

B. Posterior cerebral (or caudal) artery

This vessel appears to take origin equally from the internal carotid and basilar arteries in this specimen. From its point of commencement it passes dorsally across the optic tract to reach the interval between the optic lobe and the cerebral hemisphere and supplies both. Finally it turns around the postero-dorsal angle of the hemisphere and is distributed to the cerebral cortex. During its course it gives branches to the optic tract, the pes and to the choroid plexus of the third and lateral ventricles. In addition, it is joined in its course over the tract by the anterior choroidal artery.

Thus in the crocodile the anterior choroidal artery is not a true choroidal artery inasmuch as the choroid plexus is entirely supplied by the posterior cerebral (or caudal) artery. It should be noted that the anterior choroidal artery is very rudimentary and is closely related to the optic tract and especially the lateral geniculate body.

It was impossible, since all the arteries were equally injected, to ascertain the exact relation of the anterior choroidal artery to the lateral geniculate body.

THE *SPHENODON*

The material available was the injected brain of a *Sphenodon punctatum* and a series of transverse sections through the brain of another *Sphenodon* stained by Ranson's silver-pyridine method. As it was not desirable to destroy such a valuable specimen I merely examined the arteries in their surface distribution as far as could be done by gently pressing aside the hemispheres. For a portion of our description, then, we must be content to rely upon the excellent account given by Dendy (34).

In fig. 9, the internal carotid artery can clearly be seen to divide into cranial and caudal branches, and the basilar takes little, if any, part in the formation of the latter. The cranial artery passes anteriorly obliquely across the optic tract and, having given off the middle cerebral branch, is continued as the anterior cerebral artery. The caudal artery runs dorsally across the optic tract to enter the interval between the optic lobe and the cerebral hemisphere and is eventually dissipated by being distributed mainly over the surface of the latter. In its course the caudal artery gives branches to the optic tract, the optic lobe and cerebral hemisphere and a rich supply to the choroid plexus in the region of the foramen of Monro. It will be observed that there is no artery which can be described as being homologous with the anterior choroidal artery; that is, there is no single vessel which arises from the cranial artery, passes posteriorly along the optic tract and ends in the caudal artery.

Taking origin from the cranial division is a small vessel (indicated in fig. 9 in black) which passes dorsally between the optic tract and the medial aspect of the postero-inferior angle of the cerebral hemisphere and is then lost to sight. This artery gives twigs to the anterior part of the tract and some to the region of the amygdaloid nucleus. It is called the arteria cerebralis inferior by Dendy, and is described by him as passing to the region of the corpus striatum which it probably supplies. In addition, there is an anastomotic vessel between the middle cerebral and caudal arteries which crosses the postero-inferior angle of the hemisphere and clearly gives twigs to the amygdaloid region, and there are twigs from the caudal artery to the posterior part of the optic tract.

If all these elements were fused to form one single artery or a small network stretching from the cranial to the caudal arteries, we should have precisely the same condition as exists in the crocodile. This hypothetical composite artery would arise from the cranial artery, would run posteriorly along the optic tract and would end by joining the caudal artery. Further, in its course posteriorly, it would supply the optic tract (and the underlying lateral geniculate body), the amygdaloid nucleus and the posterior part of the corpus

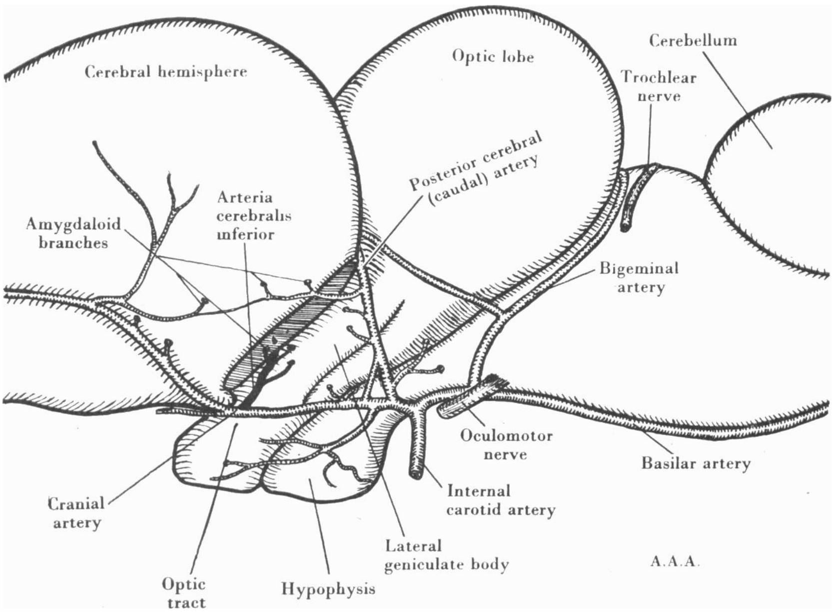

Fig. 9. Distribution of the arteries in the *Sphenodon*; the *arteria cerebralis inferior* is represented in black.

striatum and, in addition, would effect anastomoses with the middle cerebral artery. This is the condition found in the crocodile, and it is clear that in *Sphenodon* we have all the elements necessary to form a higher reptilian anterior choroidal artery, although there has, as yet, arisen no direct link with the choroid plexus. The anterior choroidal artery in the crocodile has been formed from both cranial and caudal divisions of the internal carotid artery; it is clearly a longitudinal anastomosis between the two in response to some specific demand.

Consider the development of the lateral ventricle, which can be regarded as having been drawn upwards and posteriorly between the two fixed points, the foramen of Monro and the amygdaloid nucleus. In the course of evolution both the ventricle and the choroid fissure assume an arcuate form, while the posterior pole of the hemisphere bulges backwards over the optic tectum. While this is going on the caudal artery lengthens to maintain its field of supply and, as it comes to lie alongside the lengthened choroid fissure, it supplies more and more collateral twigs through the fissure to the plexus. At the same time the posterior portion of the anterior choroidal artery, which came originally from the caudal branch, is drawn posteriorly until it, too, comes to lie alongside the elongated choroid fissure. At this juncture the posterior part of the anterior choroidal artery is called upon to take some part in the nourishment of the choroid plexus (through its phylogenetically posterior cerebral, or caudal contribution). At this stage we have reached the primitive mammalian condition and the story of the formation of the anterior choroidal artery is complete.

In ascending the mammalian scale, in keeping with the increasing growth of the lateral ventricle and the growing functional demands of the enlarging choroid plexus, the anterior choroidal artery has progressively devoted more and more of its attention to the choroid plexus. In the Marsupial, the main trunk of the anterior choroidal artery ran posteriorly to join the posterior cerebral artery, while the choroidal branches were of subsidiary importance; in the sheep, in accordance with the greater development of the antero-inferior part of the choroid plexus, the choroidal branches were larger, although the main channel still ran posteriorly to end in the posterior cerebral artery; in the apes the antero-inferior part of the choroid plexus has become so important that the anterior choroidal artery is equally divided between the plexus and its union with the posterior cerebral artery (which takes place over the lateral geniculate body); in Man we reach the terminal phase in which, while fulfilling all its original vascular requirements (optic tract, amygdaloid nucleus, anastomosis with middle cerebral artery, pes), the major trunk is devoted to the now enormously enlarged antero-inferior part of the choroid plexus. The terminal union with the posterior cerebral artery is represented merely by the lateral, intermediate and medial anastomoses over the lateral geniculate body.

We have seen that the first rudiments of the anterior choroidal artery were observed in *Sphenodon*; we have also seen that throughout its phylogenetic evolution this artery has been closely related to the optic tract and, especially, the lateral geniculate body. Cairney (35) has described the diencephalon of *Sphenodon* and has distinguished a definite pars dorsalis. While there is a well-marked pars dorsalis diencephali in Reptiles, the Amphibia possess only a mere rudiment of this structure. Cairney has also described a lateral geniculate body which has definite dorsal and ventral nuclei and it is probable that the dorsal nucleus has differentiated from the pars dorsalis diencephali of the Reptiles, that is, from the general sensory or ventral nucleus of Mammalia. In *Sphenodon* we have the first rudiments of an anterior choroidal artery associated with the first appearance of a dorsal nucleus in the lateral geniculate body (disregarding, in the meantime, the remainder of the field of supply of the artery).

The crocodile presents a rudimentary but definitely discrete anterior choroidal artery, but has it a dorsal nucleus to its lateral geniculate body? Huber and Crosby (36) describe a lateral geniculate body in the alligator, but do not state whether it is to be regarded as a dorsal or ventral nucleus or as both. The alligator is a more highly developed Reptile than *Sphenodon*, and its pars dorsalis is quite as well differentiated. I have had the opportunity of examining serial sections of the diencephalon of both the alligator and the crocodile, and it would appear that the lateral geniculate possesses both dorsal and ventral nuclei. In addition, Cairney has identified his dorsal nucleus with the lateral geniculate body described by Huber and Crosby. It thus appears that in the crocodile we have the first discrete anterior choroidal artery associated with a dorsal nucleus of the lateral geniculate body. In the Marsupial the problem is not so difficult, for we have seen the close relation of the anterior choroidal artery to the dorsal nucleus of the lateral geniculate body; the condition in the sheep is very similar.

The problem of the Primates is now simple. The anterior choroidal artery is devoted to the anterior and especially the lateral portion of the lateral geniculate body. This, as seen in the sheep and Marsupial, corresponds exactly with the field of supply of the most dorsal part of the dorsal nucleus.

SUMMARY AND CONCLUSIONS

1. The first appearance of the separate components of the anterior choroidal artery is found in *Sphenodon* in association with what is probably the first appearance of a definite dorsal nucleus of the lateral geniculate body.

2. In the crocodile these elements have fused to form a network of vessels which connects the two parent arteries—the cranial and caudal divisions—along the optic tract. The crocodile probably has a definite dorsal nucleus to its geniculate body. At this stage in phylogeny the anterior choroidal artery takes no part in the supply of the choroid plexus.

3. In the Marsupial the artery has reached a more typical stage in its development. Although the main vessel still runs posteriorly across the geniculate body to reach the posterior cerebral artery, there are some small branches which are swept aside into the now much elongated choroid fissure to reach the choroid plexus. Further, in the Marsupial the anterior choroidal artery bears a definite relation to the dorsal nucleus which is maintained throughout all successive stages.

4. In the sheep the conditions are practically the same as in the Marsupial. The increased growth of the cerebral hemispheres, associated with a consequent enlargement of the lateral ventricle and the choroid plexus, is expressed in the greater size and importance of the choroidal branches of the anterior

choroidal artery. The relation of the latter to the dorsal nucleus of the lateral geniculate body remains the same. At the same time the posterior choroidal arteries have similarly enlarged in response to the greater functional demands made upon them.

5. In the ape the anterior choroidal artery is an important vessel. Its terminal branches (not including those to the amygdaloid nucleus, pes and internal capsule) appear to be equally distributed between the now greatly enlarged choroid plexus and the lateral geniculate body. The lateral geniculate vessels anastomose, as ever, with the posterior cerebral branches which, on account of the enormous development of the choroid plexus, are mostly represented in the posterior choroidal artery. The relation of the anterior choroidal artery to the lateral geniculate body, which corresponds almost entirely to the dorsal nucleus of lower animals, is exactly comparable with that found in the latter.

6. In Man the cerebral hemispheres and the choroid plexus have so greatly enlarged that the main part of the anterior choroidal artery is devoted to the choroid plexus. The terminal branches course posteriorly over the lateral geniculate body as small twigs in the intermediate, medial and lateral anastomoses to join the posterior choroidal arteries. The latter have enlarged so much that they can be separated into three main systems of posterior choroidal arteries. The relation of the anterior choroidal artery to the lateral geniculate body (dorsal nucleus only) is the same as in the ape.

7. Finally, in Man and in apes, the distribution of the end arteries in the various laminae of the lateral geniculate body is precisely correlated with the discrete areas of functional representation of the retina.

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