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**Contributors**

Starr, M. Allen 1854-1932.  
Tweedy, John, 1849-1924  
Royal College of Surgeons of England

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W. Mead

THE VISUAL AREA IN THE BRAIN  
DETERMINED BY A STUDY  
OF HEMIANOPSIA.

BY

M. ALLEN STARR, A. M., M. D.,

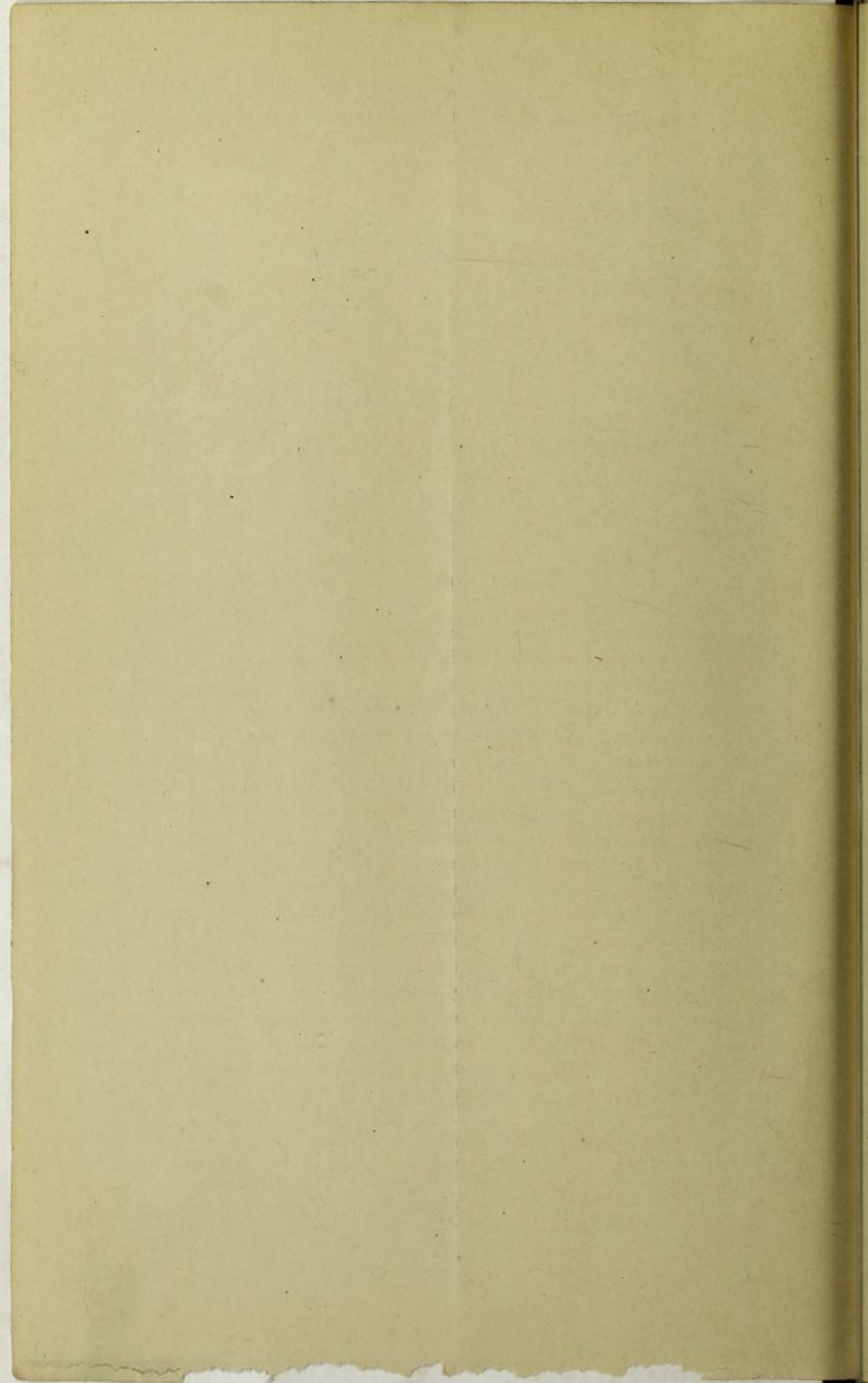
LATE HOUSE PHYSICIAN, BELLEVUE HOSPITAL, AND ATTENDING PHYSICIAN, NEW YORK DISPENSARY.

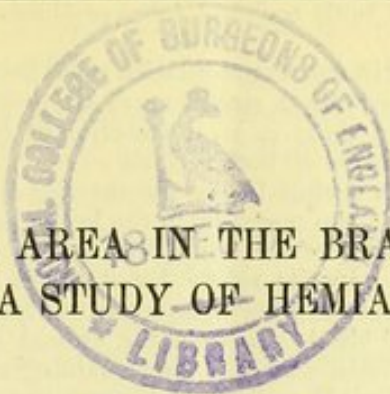


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THE VISUAL AREA IN THE BRAIN DETERMINED  
BY A STUDY OF HEMIANOPSIA.

BY M. ALLEN STARR, A.M., M.D.,  
Late House Physician, Bellevue Hospital, and Attending Physician  
New York Dispensary.

RECENT research in cerebral physiology has been directed toward the subject of the localization of sensory areas on the cortex of the brain, and has been productive of many very interesting discoveries. The investigations of Wernicke and Stilling in the anatomy of the brain, and the observations of numerous pathologists in cases of hemianopsia have confirmed in such a striking manner the conclusions of the physiologist, Munk, regarding the cortical area governing vision, that a summary of the facts deserves attention. A knowledge of these facts is necessary both for the exact examination of cases and for an accurate record of autopsies; as it seems probable that many errors in the past have been due to the imperfect investigation of symptoms and of lesions.

The experiments of Munk, first announced in 1878,<sup>1</sup> awakened so much criticism that he deemed it necessary to repeat them, especially as they differed in their results from those of Ferrier.<sup>2</sup> In 1881 a second series of researches was reported by him confirming his first conclusions,<sup>3</sup> while in the same year Ferrier was led by further experiments to modify his earlier statements,<sup>4</sup> and to bring them more nearly into accord with those of the German physiologist. At the recent July meeting of the Physiological Society of Berlin (1883) Munk made a final statement summing up the result of the work of the past seven years,<sup>5</sup> and demonstrating the accuracy of his conclusions. These may be stated as follows:—

<sup>1</sup> Verhandl. d. Physiol. Gesellsch. zu Berlin, 1878-79, Nos. 4-5.

<sup>2</sup> Ferrier, Functions of the Brain, 1876, pp. 164-171.

<sup>3</sup> Verrichtungen des Gehirns, Berlin, 1881.

<sup>4</sup> Cerebral Amblyopia and Hemiopia, Brain, Jan. 1881.

<sup>5</sup> See Report in Nature, Aug. 30, 1883.

"1. The occipital lobes of the brain are necessary for the perception of visual impressions. Destruction of both occipital lobes produces total and permanent blindness.

"2. Each occipital lobe is in functional relation with both eyes in such a manner that corresponding halves of both retinal areas are projected upon the cortex of the lobe of the like-named side; *e. g.*, destruction of the left lobe produces loss of function of the left halves of both retinae.

"3. On the cortex of each occipital lobe the anterior segment corresponds to the upper half of the retinae; the posterior to the lower half; the external half to the temporal half of the eye of the same side, and the internal half to the nasal half of the eye of the opposite side. Even though ever so small portions of the sections of the cortex in question were removed the corresponding part of the retina would be rendered blind. In time the animal learns to make up for the defects caused by operations, and with the remaining unaffected parts of the retina will contrive to see so well and act in general in such a way as to superficial observation to convey the impression of an animal endowed with normal powers of sight. On close examination, however, of the particular parts of the retina it will be found in every case that the part corresponding with the excised part of the cortex is blind. Functional restoration of an excised part of the cortex never occurs."

It is not necessary to give in detail the method pursued in reaching these conclusions. It may be stated that the animals experimented upon were dogs and monkeys, and that the results in both led to the same conclusions; it being found, however, that, as in dogs, the majority of the optic fibres decussate at the chiasm, each occipital lobe was in closer functional relationship with the eye of the opposite side than in monkeys, whose optic decussation resembles that of man in being partial. A strong point in support of these conclusions is drawn from the fact that Munk kept his animals alive for from one to five years after the operation, watching them carefully for signs of recovery, and distinguishing the temporary effects of the operation from the permanent effects of the lesion. He thus escapes the criticism which is rightly urged against the experiments of Ferrier by Goltz. The large number of animals used, the uniform result of the experiments in all cases, the length of time during which the symptoms persisted, and the minute care displayed in the observations combine to establish the truth of the conclusions reached.

It remains for the pathologist to determine whether these facts, which are true in the case of monkeys, are true also in the case of man. Nature's experiments in the form of disease, when carefully studied, supply the necessary conditions and facts to determine this question. During the past four years a large number of cases have been reported with full records of autopsies, which are of great value in establishing the fact that the function of vision in man is performed by the occipital lobes of the brain. Before examining these cases, however, a brief review of the anatomy of the optic tract may be of service, in order to call attention to a recent discovery of Wernicke.

It has long been taught that the decussation of the optic nerves in the chiasm is partial; and that the optic tracts, beginning at the chiasm, terminate in the corpora geniculata, in the posterior *outer* third of the optic

thalamus (the pulvinar), and in the corpora quadrigemina.<sup>1</sup> The direct connection of these central ganglia with the cortex by means of a white tract passing outward from the thalamus and backward to the occipital lobe has been lately proved by Wernicke.<sup>2</sup> His discovery is confirmed by Stilling and Wilbrand, and is a striking confirmation of the earlier statements of Gratiolet and Meynert, Fig. 1. It is therefore possible to follow the course of the optic fibres from the chiasm to the occipital lobe. This course is further corroborated by a case reported by Huguenin,<sup>3</sup> in which, after blindness of the left eye of fifty years' duration, both occipital lobes were found to be atrophied. The atrophy consisted of a diminution both in the size of the convolutions and in the thickness of their cortex, and was greater in the right hemisphere. The test of pathology thus establishes the existence of a direct anatomical connection between one eye and both occipital lobes. Several cases of atrophy of both occipital lobes after total blindness of long duration are on record.<sup>4</sup> It would therefore appear to be a matter of anatomical necessity that impressions received in each eye should be conveyed to both occipital lobes of the brain.

But pathology furnishes even more convincing proof of the functional connection of the occipital lobes with vision. The peculiar symptoms of blindness in the corresponding halves of both eyes, called "lateral homonymous hemianopsia," was long thought to be due in every case to a destruction of one optic tract.<sup>5</sup> Prior to five years ago all the cases on record supported this conclusion. Since that time numerous cases have been published which demonstrate that it may also be produced by a lesion of the pulvinar of one optic thalamus, or by a lesion of one occipital lobe, situated either in its white matter (*i. e.*, in the direct tract of Wernicke) or in its cortex. They also prove that each occipital lobe is in functional connection with both eyes, and not with the eye of the side opposite to it only, as has been formerly supposed. No summary of these cases has appeared in English. In order to demonstrate their value in determining the visual area of the brain they are cited here; only those cases being given which are accompanied by a record of autopsy.

#### I. *First Group. Hemianopsia with Lesion of one Optic Thalamus.*

CASE 1. Male, æt. 62. Left hemianopsia; field of vision limited by a vertical line passing through the fixation point. No other symptoms.

<sup>1</sup> The existence of fibres from the optic tract to the pons and olivary body—the *radix descendens nervi optici* of Stilling—is still under examination. It is uncertain whether the fibres passing from the tract to the basal optic ganglia of Meynert and to the corpora Luysii are connected with sight.

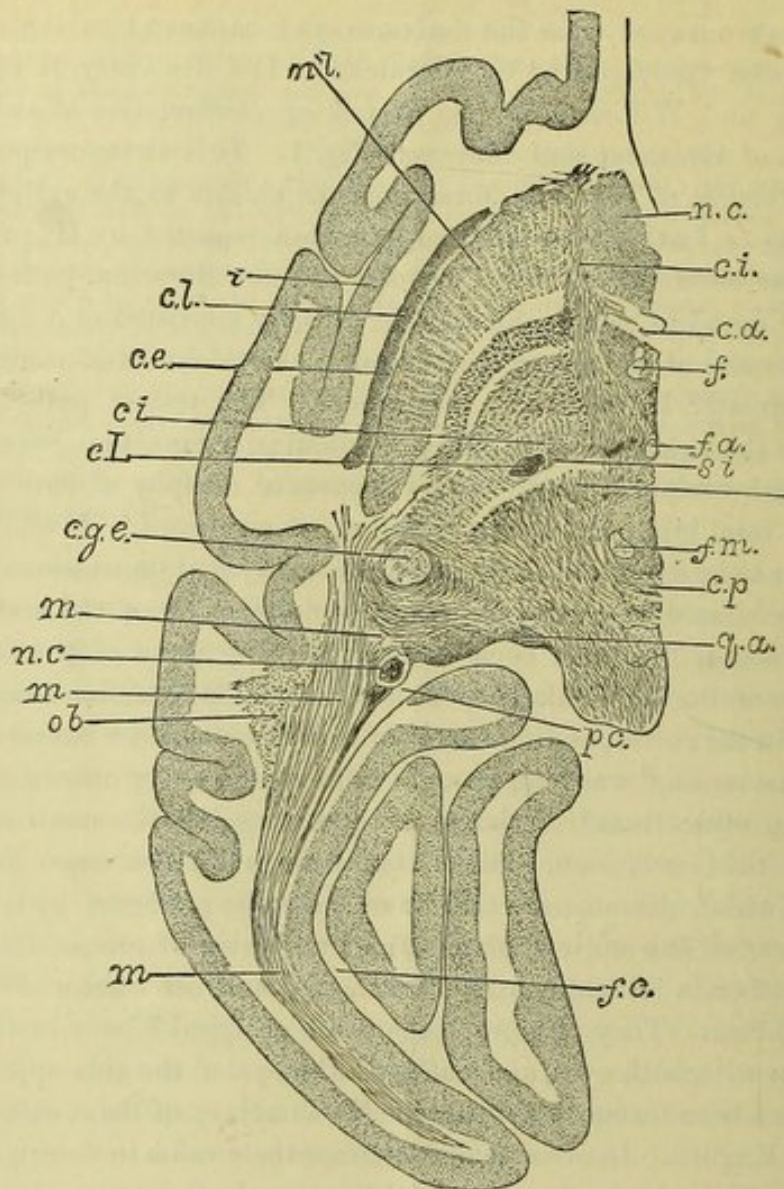
<sup>2</sup> Wernicke, *Gehirnkrankheiten*, Anatom. Theil. i. pp. 79-85, 1881.

<sup>3</sup> Nothnagel, *Topische Diagnostik d. Gehirns*, p. 476.

<sup>4</sup> Nothnagel, *Topische Diagnostik d. Gehirns*, s. 389. Griesinger, *Hirnkrankh.* s. 365. Moore, *Jahresbericht v. Virchow*, xiv. i. 91. Mickle, *Med. Times and Gaz.*, 1882, Jan. 28; in this one alone were the angular gyri also involved.

<sup>5</sup> This error is reaffirmed by A. L. Ranney, M.D., *N. Y. Med. Record*, Aug. 18, 1883.

Fig. 1.

HORIZONTAL SECTION OF A BRAIN OF A MONKEY. (After Wernicke.  $\frac{2}{3}$ .)

*n. c.* Nucleus caudatus; *c. i.* capsula interna; *f.* fornix; *f. a.* fornix ascendans; *c. a.* commissure anterior; *c. p.* com. posterior; *s. i.* bundle of fibres from *n. l.* to the tegmentum; *f. m.* Meynert's bundle; *q. a.* corp. quadrigemina ant.; *p. c.* posterior cornu of lateral ventricle; *f. c.* fissura calcarina; *o. b.* crosscut fibres to lower occipital lobe; *m.* direct medullary fibres to occipital lobe; *c. g. e.* corp. genic. ext.; *c. l.* corpus Luysii; *c. e.* capsula externa; *c. l.* claustrum; *i.* island of Reil.

*Autopsy.*—Hemorrhage in the posterior part of the right optic thalamus, and in the corpus striatum. Optic tracts normal. (Pflüger; *Augenlinik in Bern*, 1878, cited by Marchand. *Graefe's Archiv für Ophthalmologie*, xxviii. 2.)

CASE 2. Male, æt. 75. Left hemianopsia; field of vision limited by a line passing vertically through the fixation point. Other symptoms: left hemianæsthesia and hemiparesis. Symptoms all remained three years.

*Autopsy.*—Area of softening with atrophy, limited strictly to the posterior half of the right optic thalamus, and destroying the pulvinar. All other parts of the brain, including the optic tracts, normal. (Hughlings-Jackson, *Lond. Ophthal. Hosp. Rep.*, viii.)

CASE 3. Male, æt. 50. Left hemianopsia coming on suddenly, and associated with aphasia, left hemiplegia and anæsthesia of left arm and leg. The loss of vision in the left half of both fields of vision was complete, and was limited by a vertical line passing just to the left of the point of fixation. Central vision good. Pupils normal. The aphasia disappeared, but the hemiplegia increased in degree until death, two weeks after the attack.

*Autopsy.*—Oval clot 4 x 3 x 3 lines was found in the posterior and upper extremity of the right optic thalamus, quite within the pulvinar. Corp. quad., corp. genic., and optic tracts normal. Three other small hemorrhagic spots were found in the right centrum ovale in the course of the motor fibres passing to the central convolutions. These were the cause of the hemiplegia, while the hemianopsia was due to lesion of the thalamus. (Dreschfeld, *Brain*, vol. iv., No. 4, p. 549.)

CASE 4. Male, æt. 55. Right hemianopsia; field of vision limited by a vertical line passing through the fixation point. Other symptoms: paresis of entire right half of body; anæsthesia of right arm; disturbance of speech; epileptiform convulsions and mania. Death after seven months.

*Autopsy.*—Tumour (gumma) in the left occipital lobe, surrounded by a very extensive zone of softening which involved the parietal lobe, and extended inward to the left optic thalamus, which was softened. Optic chiasm and tracts normal. (Pooley, *Knapp's Archiv. of Ophthalm.*, vi. p. 27.)

CASE 5. Male, æt. 42. Right hemianopsia; central vision good. Other symptoms: aphasia; right complete hemiplegia, with facial paralysis.

*Autopsy.*—Tumour in left occipital lobe surrounded by a zone of softening reaching inward to and involving the pulvinar of the left optic thalamus. Optic tracts normal. (Hirschberg, *Deut. Zeitsch. f. Prac. Med.*, 1878, No. 4.)

The last two cases would be placed in our second group, did not both Pooley and Hirschberg refer the hemianopsia to the lesion of the optic thalamus.

## II. Second Group. Lesions of the Occipital Lobe.

CASE 1. Male, æt. 64. Right hemianopsia with right hemiplegia and aphasia.

*Autopsy.*—An embolus in the left sylvian artery had produced an area of softening in the left hemisphere, involving the corpus striatum, external capsule, and centrum ovale. An area of softening was also found in the anterior part of the left occipital lobe in its white substance. Island of Reil, optic tracts and chiasm normal. (Förster, cited by Grasset; *Montpellier Medical*, Feb. 1883.)

CASE 2. Female, æt. 46. Right hemianopsia, limited by vertical line through fixation point. Other symptoms: aphasia; complete right hemiplegia with anæsthesia, following a sudden loss of consciousness, with right unilateral convulsion. Patient lived three months after.

*Autopsy.*—Embolus in the left sylvian artery, with softening of the area supplied by it, viz., the posterior part of the inferior frontal; the inferior part of both central; the anterior part of the gyrus supra marginalis and the island of Reil. The area of softening extended inward to the nucleus lenticularis, and backward into the white matter of the parietal lobe. (Huguenin, *Ziemssen's Cyclop.*, xi. p. 797.)

The area of softening probably reached the direct medullary tract of Wernicke lying beneath the supra-marginal gyrus at its posterior extremity, and thus produced the hemianopsia in both of these cases.

CASE 3. Right hemianopsia occurring suddenly, with headache and drowsiness. Later aphasia developed.

*Autopsy.*—In the left hemisphere a hemorrhage had destroyed the greater part of the corona radiata, including the posterior fibres to the occipital lobe, and had penetrated into the parietal lobe, nearly reaching the island of Reil. Other parts of the brain normal. (Dmitrowsky, cited by Wilbrand, *Hemianopsie*, p. 477.)



CASE 4. Female, æt. 69. Sudden attack of complete right hemiplegia, with anæsthesia, including the face, followed by left hemichorea of both arm and leg, which persisted during sleep, and left a hyperæsthesia. The left eye had long been blind from pannus, but a lateral right hemianopsia of the right eye accompanied the apoplectic attack. The hearing was diminished in the right ear. Patient was very stupid, but lived 32 days after the attack.

*Autopsy.*—The entire left occipital lobe, the parietal convolutions, and the central convolutions were softened from embolism of the art. fossa. syl. and the art. med. sinist. The basal ganglia and the internal capsule, in its entire extent, were included in the softened area. (Birch-Hirschfeld, cited by Vetter. *Deut. Arch. f. Klin. Med.*, xxxii. 507.)

CASE 5. Female, was suddenly seized with amnesic aphasia, without any affection of motion or sensation. Smell and taste were normal, but she no longer looked directly at objects or persons, but constantly kept both eyes turned to the left, there being, however, no paralysis of the ocular muscles. In grasping things to the right of her she would miss them, and have to correct herself by turning her head, in order to see them. Ophthalmoscopic examination negative. The author attributed the position of the eyes to right hemianopsia.

*Autopsy.*—Embolism of the parieto-sphenoid branch of the left sylvian artery. The entire left lower parietal lobule was softened, especially in its cortex, and the softening encroached upon the cortex of the second occipital convolution to a considerable extent. (Fritsch, cited by Wilbrand, *Hemianopsie*, p. 144.)

CASE 6. Male, æt. 50. Right hemianopsia. Other symptoms were aphasia, complete loss of muscular sense in the right arm, and attacks of right unilateral convulsions which left the patient hemiplegic for a few days, after which he would regain his power in the right side. Death occurred several months after.

*Autopsy.*—The pia mater was adherent over the entire left hemisphere, and the cortex was in a condition of yellow softening, and was atrophied in the entire parietal, in the greater part of the occipital, and in a portion of the temporo-sphenoidal regions. The angular gyrus was less involved than the other parts. Westphal refers the hemianopsia to the lesion of the occipital lobe. (Westphal, *Charité Annalen*, 1882. *Brain*, July, 1882, p. 281.)

CASE 7. Hughes reports a case in which, after a compound fracture of the skull in the occipital region, two pieces of bone were elevated and removed on the left side. There was much laceration, and some loss of brain-substance in this region. The patient recovered, but a right hemianopsia remained. Cited by Wilbrand. (*Hemianopsia*, p. 142.)<sup>1</sup>

CASE 8. Male, æt. 64. Right hemianopsia, limited by a vertical line passing 5° to the right of the fixation point. To the right of this line was a zone 10°-15° broad in both eyes, in which perception of light was possible, though much impaired. The periphery of the visual field of the left eye was narrowed about 5°-10°. This condition continued twenty months, during which the degree of the hemianopsia varied somewhat, the width of the vertical zones of indistinct vision and the peripheral defect in the left eye at times decreasing and then recurring. The limiting line did not change its position. Other symptoms were at first agraphia, aphasia, and alexia, of which the first only had disappeared at the time of death. Toward the close of life, a right hemiplegia developed gradually, affecting the arm more than the leg.

*Autopsy.*—A softened area on the cortex of the posterior part of the left hemisphere involved the occipital, parietal, and temporal convolutions, at their junction, two-thirds of it being located in the occipital cortex, upon the convexity. The area was irregular in outline, and did not destroy the angular gyrus. The centre of the convexity of the occipital lobe was its principal seat, but the convolutions joining the occipital lobe with the second temporal and inferior parietal, as well as the posterior parts of both these convolutions, were involved. The softening extended inward through the white substance, and reached the

<sup>1</sup> A similar case is reported by Nieden, *Graefe's Arch. f. Ophthal.*, xxix. p. 143. The case of Keen and Thompson, *Surg. Hist. of the War*, I. 270, is without autopsy, and the course of the ball was too indefinite to warrant any conclusion as to the lesion.

ependyma of the post. cornu of the lateral ventricle, thus involving the direct medullary tract of Wernicke for a breadth of two cm. A second area of softening in the external capsule encroached on the nucleus lenticularis, and the anterior part of the internal capsule. In the white matter of the anterior central convolution were two more small centres of softening. A descending degeneration was followed from the internal capsule into the pons. Thalamus and optic tract normal. (Wernicke, *Gehirnkrankheiten*, ii. 190-195.)

CASE 9. Male, æt. 42. Right hemianopsia not quite reaching the point of fixation. Central vision good in both eyes. Ophthalmoscopic examination negative. Other symptoms: vertigo, loss of memory, aphasia, and partial agraphia with temporary right hemiplegia.

*Autopsy.*—In the left occipital lobe, involving all three of its convolutions, as well as the præcuneus, was found a gelatinous sarcoma. A wedge-shaped area of softening extended inward through the white substance to the posterior cornu of the lateral ventricle. Thalamus and optic tracts normal. (Jastrowitz, *Arch. f. Augenheilkunde*, 1877, p. 254.)

CASE 10. Male, æt. 51. Right hemianopsia limited in the left eye by a line passing through the point of central vision, and in the right eye by a line passing  $10^{\circ}$  to the right of this point. Ophthalmoscopic examination negative. Other symptoms: monoplegia of the left arm, with vaso-motor paralysis. The paralysis was referred to a loss of the muscular sense. No disturbance of sensibility but paræsthesiæ of the entire arm. Gradual development of a condition of dementia and apparent increase of the degree of blindness, the extent of which could not be determined, on account of the mental condition of the patient. Death after two months.

*Autopsy.*—The entire left occipital lobe as far forward as the sulcus parieto-occipitalis, both on its surface and in its substance, was found in a condition of yellow and grayish-white softening. A second area of softening, involving the middle third of the right anterior central convolution, explained the monoplegia. Two other small areas of softening were found in the right hemisphere: one in the superior parietal lobule; the other in the third occipital convolution. A recent hemorrhage in the right optic thalamus was the cause of death. Optic tracts normal. (Nothnagel, *Topische Diagnostik d. Gehirnk.*, p. 390.)

CASE 11. Male, æt. 45. Right hemianopsia. Other symptoms developed later were right hemiparesis with anæsthesia going on to complete hemiplegia. Fever and headache. Diagnosis was made of an abscess in the left occipital lobe. The left parietal bone was trephined at its post. sup. angle; the abscess was found and evacuated, with temporary relief of the hemiplegia. The hemianopsia remained till death, two weeks after the operation.

*Autopsy.*—In the left occipital lobe involving also the posterior part of the inferior parietal lobe was found an abscess of tubercular origin with ragged walls. On the convexity of the left occipital lobe numerous tubercles were found embedded in the cortex. Optic thalami and tracts normal. (Wernicke u. Hahn., *Virchow's Archiv*, vol. 87, p. 335.)

CASE 12. Female, æt. 21. Right hemianopsia. Central vision good. Other symptoms: headache, dysarthria, anæsthesia of the right half of the face. No paralysis; no mental symptoms. Choked disks. Death after seven months.

*Autopsy.*—A cystic glioma was found in the left occipital lobe which had reached and destroyed the cortex of the lobe at its apex, and had extended inward nearly reaching the inferior cornu of the lateral ventricle. The entire inner half of the occipital lobe was thus destroyed. (Jany, *Knapp's Archiv f. Augenheilk.*, xi. p. 190.)

CASE 13. Female, after an apoplectic attack was unable to talk distinctly, was partly paralyzed in the right hand, and unable to perceive sensations in the right half of the body. She only saw one half of objects. This condition lasted two and a half years, when after a second apoplexy accompanied by total right hemiplegia she died of pneumonia. The hemianopsia continued till death.

*Autopsy.*—Membranes not adherent to the brain. On the median surface of the left occipital lobe there was a large area in which the brain substance was missing; and the lateral ventricle was separated from the pia mater only by a thickened endyma to which debris of brain tissue was adherent. A cyst was

found in the right superior lobe of the cerebellum. Other lesions of a more recent date were two small centres of softening in the left optic thalamus, and a small cyst in the left corpus striatum. (Chaillou, *Bull. d. l. Soc. Anat. de Paris*, 1863, Feb. *Procès Verbal.*<sup>1</sup>)

CASE 14. Male, æt. 69, was admitted to la Charité Hospital, Berlin, four months after an attack of left hemiplegia with partial aphasia; when in addition to these symptoms and mental weakness it was noticed that the patient's eyes were constantly turned to the right, though the muscles of the eyes were not paralyzed. Examination revealed a left hemianopsia. Sensation on the left side could not be tested on account of his mental condition. Later ataxia and paresis of the right arm and leg developed, and febrile symptoms with delirium terminated in death six months after the attack.

*Autopsy.*—General atrophy of the convolutions. Arteries atheromatous. In the middle of the second right temporal convolution a discoloration was visible; and on section a large hemorrhagic spot of softening was found which had destroyed the greater part of the substance of the temporal lobe, and had extended backward into the occipital and upward into the parietal centrum ovale without breaking into the lateral ventricle. Internally it had destroyed the posterior third of the internal capsule and the direct medullary tract of Wernicke without involving the optic thalamus. The right corpus geniculatum externum was in a state of red softening. The third member of the nucleus lenticularis and the external capsule were also injured. (Senator, cited by Wernicke, l. c. ii. 70.)

CASE 15. Female, æt. 70, after an apoplectic attack lost the powers of motion and sensation in the entire left half of the body. There was ptosis of the left eyelid and apparent blindness of the left eye, but with the right eye patient could see. During the following fortnight the powers of sensation and motion returned, excepting in the left arm; the ptosis disappeared, and vision was partly regained in the left eye. It was then found that the patient had left hemianopsia in both eyes. Subjective sensations of light annoyed her much. In the left arm contracture of the flexors developed. Headache increasing in intensity was followed by convulsions, and in three weeks the patient died.

*Autopsy.*—The right hemisphere was much softer than normal, especially in the white matter on the roof of the lateral ventricle; and the softening reached as far back as the posterior part of the occipital lobe. The right optic thalamus, and a part of the lenticular nucleus were also softened. There was also a small area of softening "in the upper part of the left hemisphere." Nowhere any hemorrhages. No ventricular effusion. (Lallemande, cited by Wernicke, l. c. ii. 189.)

CASE 16. Male, æt. 40. Suffered for seven years before death from epileptic seizures beginning with spasm of the left leg, and going on to general convulsions, in which, however, the motions were always more violent on the left side. An aura consisting of a darkness coming gradually over the field of vision from the left side always preceded the attack. During the intervals left-sided headache was the chief symptom. It seems probable that a temporary left hemianopsia preceded the attack.

*Autopsy.*—In the white matter of the right occipital lobe was found a cyst of the size of an apple, filled with serum, and surrounded by a zone of softening which did not involve either the cortex or the wall of the lateral ventricle. All other parts of the brain normal. (Traube, *Gesammt. Beiträge zu Pathologie*, ii. 1083.)

CASE 17. Male, æt. 72. Left hemianopsia occurring suddenly with left hemiplegia. Patient lived several months without recovering.

*Autopsy.*—Pia mater over the right occipital lobe congested but not adherent.

<sup>1</sup> The side on which the hemianopsia was is not stated in the original. The report is: "Elle ne pouvait plus voir à la fois, disait elle, deux objets faiblement éloignées l'un de l'autre, et n'apercevait constamment qu'une moitié de la figure des gens qui la regardaient." M. Bellouard, *L'Hémianopsie*. Thèse de Paris, 1881; cites the case as one of left hemianopsia. It must have been a right hemianopsia judging from the lesion found.

The convolutions posterior to the fissure of Rolando, on the right side, were softened and the vessels injected. At the apex of the right occipital lobe was a spot of necrosis of the size of a hazel-nut, surrounded by a zone of yellow degeneration which extended over the surface of the neighbouring convolutions on the convexity of the lobe. The softening was superficial, and did not extend deeply into the white matter. A small cysticercus 5 mm. in diameter was found on the inferior surface of the left anterior lobe external to the olfactory bulb; no other lesion. The optic thalami and tracts normal. (Marchand, *Graefe's Arch. f. Ophthalm.*, xxviii. 2.)

CASE 18. Female, æt. 8, of tubercular parentage, became irritable and stupid, began to suffer from headache, and two months later was attacked with general convulsions which occurred every few days. Her mental condition became much impaired, but no paralysis or anæsthesia was detected. For six weeks before her death there was left hemianopsia,

*Autopsy.*—A tubercular tumour 3 by 3 by 2.5 cm. was found on the median surface of the apex of the right occipital lobe in the sulcus hippocampi whose sides it separated. It was surrounded by a zone of yellowish-red softening which was limited to the cortex and did not involve the white matter. A second smaller tubercle lay at the apex of the right second frontal convolution. Optic thalami, tracts, and chiasm normal. (Haab, *Klin. Monatsbl. f. Augenheilk.*, xx. 5.)

CASE 19. Female, æt. 61. Left hemianopsia occurring suddenly with left hemiplegia. The latter disappeared, but the former remained one year, until death. The field of vision was limited by a vertical line passing through the fixation point in both eyes.

*Autopsy.*—On the median surface at the apex of the right occipital lobe was found a cyst surrounded by an extensive oval area of softening measuring 6 by 3 cm. The cortex about the sulcus hippocampi was destroyed. The softening was limited to the cortex, a tract of normal white substance lying between it and the posterior cornu of the lateral ventricle. The optic thalami, corp. quadrigemina and geniculata, and the optic tracts normal. (Haab, *Klin. Monatsbl. f. Augenheilk.*, xx. 5.)

CASE 20. Male, æt. 32. After an apoplectic attack accompanied by fever there remained left hemianopsia with left hemiparesis. During the next three months the patient suffered from left unilateral convulsions at intervals. Then after such a convulsion right hemianopsia appeared, leaving the patient totally blind until his death one month after. Convulsions of the right arm and face occurred during the last month, and twice the patient had visual hallucinations. There was no other sensory disturbances.

*Autopsy.*—The brain was œdematous. The pia mater was thickened and opaque in spots over the convexity. Over the left parietal and both occipital lobes the pia mater was deeply congested and firmly adherent to the cortex so that the latter was torn in removing it. The entire cortex of both occipital lobes was very soft and markedly atrophied, the right one more than the left. The medullary substance of both occipital lobes was soft and atrophied, and the post. cornua of the lateral ventricles were distended with serum. Both optic thalami were soft and atrophied in their posterior third. Both optic tracts normal. (Stenger, *Arch. f. Psych.*, xiii. s. 245.)

CASE 21. Male, æt. 52, who had been subject to epilepsy for years, had an attack of left unilateral convulsions without loss of consciousness, followed by paresis of the left leg, paralysis of the left arm, and paræsthesiæ in the left hand. The unilateral convulsions recurred daily for 13 days, when left hemianopsia suddenly developed, and a total loss of muscular sense in the left hand occurred. The paresis gradually disappeared, but the hemianopsia persisted till his death six months after.

*Autopsy.*—Hydrocephalus. Pia mater opaque and adherent over the right parietal lobe, posterior to the central convolutions, and over the anterior part of the occipital lobe to within 3 cm. of its apex. In this region the cortex was soft, yellowish-gray, and much atrophied. The softening encroached on the cortex of the first temporal convolution inferiorly. The right posterior cornu of the lateral ventricle was distended with serum, and its walls were macerated. The right

optic thalamus was softer and flatter than the left. Optic tracts normal. (Stenger, *Arch. f. Psych.*, xiii. p. 247.)

CASE 22. Male, æt. 50, was suddenly attacked with left hemianopsia, there being no other brain symptoms. The field of vision was limited by a vertical line passing through the fixation point of each eye. Central vision good. Ophthalm. exam. negative. Patient died two weeks after of heart disease.

*Autopsy.*—A large area of softening was found in the right occipital lobe, which extended to the surface on the median side and also to the apex. Optic thalami and tracts normal. (Curschmann, *Centralbl. f. prac. Augenheilk.*, 1878, s. 181.)

CASE 23. Male, æt. 44, noticed on rising one morning a disturbance of vision which was found to be a left hemianopsia. The field of vision was limited by a vertical line passing through the fixation point in both eyes. Central vision and colour sense good. No other brain symptoms. Died several months after, never having recovered his vision.

*Autopsy.*—An old apoplectic cyst the size of a walnut was found in the right occipital lobe. Its upper wall consisted of the three occipital convolutions which were in a condition of yellow softening. Its inner wall did not reach the lateral ventricle. A small apoplectic cyst was also found in the centre of the right optic thalamus; and a pea-sized spot of red softening in the roof of the anterior cornu of the left lateral ventricle. (Baumgarten, *Centralbl. f. d. med. Wissen.*, 1878, No. 21.)

CASE 24. Male, æt. 42, suffered from left unilateral convulsions without loss of consciousness and temporary left hemiplegia with loss of sense of pain after each convulsion. During the convulsion, patient was aphasic. In June, 1878, left hemianopsia appeared after a convulsion, and continued till his death in April, 1879. During the last few months there was a slight contracture of the left arm.

*Autopsy.*—The convolutions posterior to the fissure of Rolando on the right side were atrophied and sunken in, and the white matter beneath was softened. The area of softening included the entire white substance of the occipital lobe and of the superior and inferior parietal convolutions. Thalami optici, corpora striata, and int. capsule intact. Microscopic examination showed the optic tracts to be normal. No other lesion. (Westphal, cited by Wernicke, *loc. cit.*, ii. 195.)

CASE 25. Male. Left hemianopsia not quite reaching the fixation point. Left hemiplegia. Death after three years.

*Autopsy.*—In the right occipital lobe, posterior to and not involving the optic thalamus, was a large cavity with smooth walls communicating with the inferior cornu of the lateral ventricle. It was found to be the remains of an apoplectic cyst which had destroyed the greater part of the occipital lobe. Corpora amygdacea were found on the surface of the chiasm. Both optic tracts normal. (Hosch, cited by Marchand, *Graefe's Arch. f. Ophth.*, xxviii. 2.)

CASE 26. Male, æt. 40, suffered from headache, dizziness, and drowsiness for nine months after receiving a blow on the head; but not to a degree sufficient to interfere with his profession, which was that of a musician. He was then suddenly seized with severe headache and left hemianopsia. No other brain symptoms developed, but these persisted, and the patient went into a condition of coma, and died in eleven days.

*Autopsy.*—In the right occipital lobe was found a large abscess one-and-a-half inch in diameter inclosed in a firm wall of connective tissue. It was situated superficially, and caused a bulging of the convex surface of the lobe. It contained pus and granular matter. A second smaller abscess of the size of a hickory-nut was found in the left anterior lobe surrounded by a zone of softened tissue. No other lesion. (Levick, *Amer. Journ. Med. Sci.*, 1866, Oct.)

CASE 27. Prevost reported a case to the Soc. Med. of Geneva, in 1878, in which left hemianopsia was definitely determined. There was found at the autopsy an extensive lesion of the right occipital lobe, and also a lesion of the optic thalamus on its posterior part involving the corpus geniculatum externum. (Cited by Ferrier, *Brain*, ix. 97.<sup>1</sup>)

<sup>1</sup> The report is very imperfect. I give it as stated by Ferrier, having been unable to obtain the original.

Cases of hemianopsia produced by lesions of one optic tract are so well known and so frequently reported, that it is not necessary to cite them here. The fact that this lesion produces hemianopsia is now admitted by all authorities. For recent cases see Graefe's *Arch. für Ophth.*, xxviii. 2. From an analysis of these cases, the following conclusions regarding the pathology of hemianopsia may be reached:—

Lateral homonymous hemianopsia may be produced not only by a lesion of one optic tract, but also by a lesion situated either in the pulvinar of one optic thalamus;<sup>1</sup> in the posterior part of one internal capsule or its radiation backward toward the occipital lobe;<sup>2</sup> in the medullary portion of the occipital lobe;<sup>3</sup> or in the cortex of one occipital lobe.<sup>4</sup> Extensive or multiple lesions<sup>5</sup> involving two or more of these portions of the brain produce the same symptom. Hence, a lesion in the course of the optic fibres of one side, at any point between the optic chiasm and their termination in the cortex of the occipital region, produces partial blindness of both eyes. It is, therefore, justifiable to conclude that the occipital lobe of each side is in anatomical and functional relation with both eyes; in such a manner that the like-named sides of both retinae are connected with the like-named hemisphere, *e. g.*, the right sides of both retinae with the right hemisphere, and *vice versa*. When a lesion of one hemisphere involves the optic fibres, at any point, partial blindness of both eyes, and not blindness of the opposite eye, is produced.

These conclusions are forced upon us by a study of these thirty-two cases. They conflict with the statement of Charcot as to the course of the optic nerve-fibres;<sup>6</sup> and with the statement of Ferrier that the angular gyrus is the centre of sight in man, and governs the eye of the opposite side.<sup>7</sup> These statements must, therefore, be examined.

Charcot's scheme (Fig. 2), in which all the fibres from one eye are seen to meet in the hemisphere of the opposite side, was proposed in order to explain the symptom of crossed amblyopia (*i. e.*, partial blindness in the eye opposite the lesion), observed in cases of hysterical hemianæsthesia. It was not based upon any post-mortem discovery of a lesion in one hemisphere producing the symptom; and Charcot himself stated that it had no anatomical basis.<sup>8</sup> Subsequent examination of the same cases by Landolt revealed the fact that there were visual defects in both eyes instead of in one;<sup>9</sup> a fact which at once invalidated the accuracy of the

<sup>1</sup> Cases I. 1, 2, 3.

<sup>2</sup> Cases II. 1, 2, 3, 4, 14.

<sup>3</sup> Cases II. 15, 16.

<sup>4</sup> Cases II. 5, 6, 7, 17, 18, 19, 20, 21.

<sup>5</sup> Cases I. 4, 5; II. 8, 9, 10, 11, 12, 13, 22, 23, 24, 25, 26, 27.

<sup>6</sup> Charcot, *Le Progrès Medical*, 1875, p. 705. Also *Localisation des Mal. Cerebrales*, pp. 116-127.

<sup>7</sup> Ferrier, *Localization of Brain Diseases*, pp. 116-120.

<sup>8</sup> Charcot, *loc. cit.*, page 127.

<sup>9</sup> Landolt, *La France Médicale*, Feb. 3, 1877. Also cited by Charcot, *loc. cit.*, p. 119.

Fig. 2.

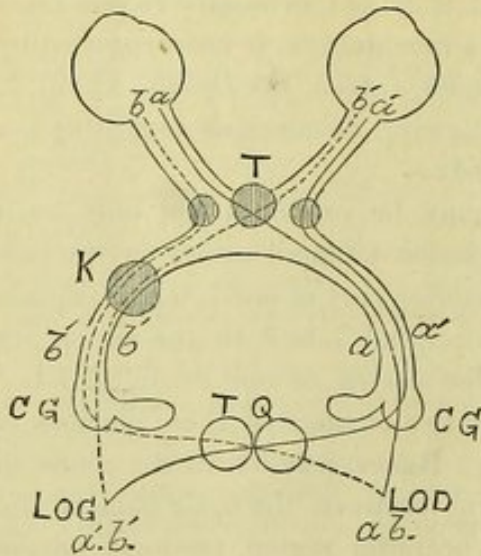


Fig. 3.

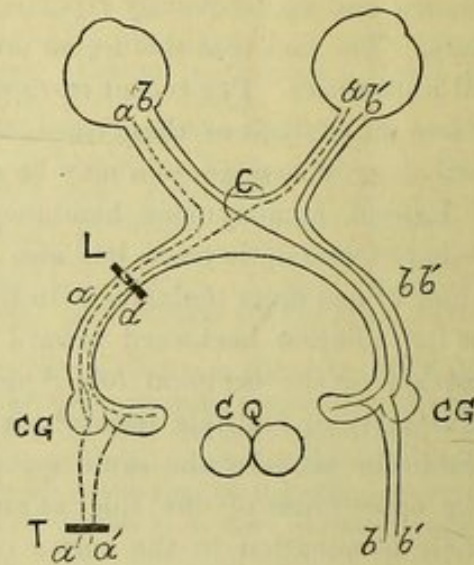


Fig. 2. SCHEME OF THE DECUSSATION OF THE OPTIC TRACTS. (According to Charcot.)—*T.* semi-decussation in the chiasm; *T. Q.* decussation posterior in the corpora quadrigemina; *C. G.* corpora geniculata; *a'b.* fibres which do not decussate in the chiasm; *a. b.'* fibres which decussate in the chiasm; *a' b.'* fibres from right eye meeting in left hemisphere, *L. O. G.*; *K.* lesion of left optic tract crossing right lateral hemianopsia; *L. O. G.* lesion of left hemisphere producing right amblyopia.

Fig. 3. DECUSSATION OF OPTIC FIBRES. (According to Graefe and Féré.)—*C.* semidecussation at the chiasm; *C. G.* corpora geniculata; *L.* lesion in optic tract; *T.* lesion in left hemisphere producing right lateral hemianopsia; *C. Q.* corpora quadrigemina.

scheme. An examination of the figure shows that it is inadequate to explain the course of the optic nerve-fibres if the conclusions here reached are admitted. That Charcot himself believes it to be wrong is shown by his approval of the recent essay of his pupil Féré,<sup>1</sup> which proposes to substitute for it the older scheme announced by Graefe in 1860, Fig. 3. The scheme of Charcot is no longer taught in Germany<sup>2</sup> or in France,<sup>3</sup> and is given up by its author. It is therefore needless to discuss it.<sup>4</sup> The symptom which it sought to explain must, however, be examined, as it too stands in opposition to the facts here demonstrated, and forms the basis of a new scheme proposed in February, 1883, by Grasset.<sup>5</sup> Grasset claims that there are several cases on record in which an autopsy has shown that a lesion of one hemisphere, in the internal capsule, may produce blindness in the opposite eye. He cites four cases, which are as follows:—

<sup>1</sup> Féré, *l'Hémianopsie*, Paris, 1882.

<sup>2</sup> See Mauthner, *Gehirn und Auge*, 1881. Wien. Wilbrand, *Hemianopsie*, 1881, Berlin.

<sup>3</sup> See *Archiv. d'Ophthalmologie*, August, 1883, p. 368. Bellouard, *l'Hémianopsie*, Paris, 1881.

<sup>4</sup> Prof. Ranney, however, seems to regard it as true. See *N. Y. Med. Record*, Aug. 18, 1883.

<sup>5</sup> Grasset, *Montpellier Medical*, 1883, Feb.

1. Right hemiplegia with aphasia and right hemianæsthesia. "The right eye appeared blind; in the left eye the field of vision was much decreased in extent." (Bernhardt, *Berlin klin. Woch.*, 1875, No. 36.)

2. Right hemiplegia and hemianæsthesia. "With the right eye the patient can see only very large letters; left eye normal." (Muller, *Berlin klin. Woch.*, 1878, p. 284.)

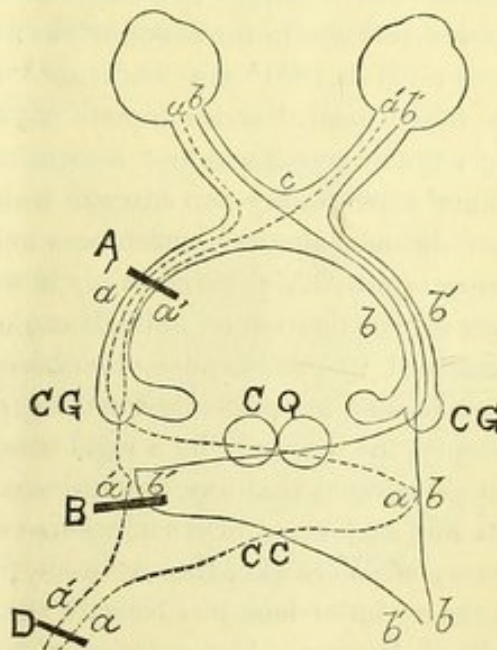
3. Right hemianæsthesia and hemichorea. "The visual power is  $\frac{1}{2}$  in the left eye,  $\frac{1}{4}$  in the right eye. Both visual fields are contracted for white light and for colours, but the right is wider than the left." (Féré, *Hémianopsie*, Paris, 1882, Obs. LXVIII.)

4. Right hemianæsthesia and hemiathetosis. "Diminution in the visual power in the right eye." (Ballet and Féré. Féré, l. c. Obs. LXI.)

It is evident that these cases fail utterly to establish his conclusion. In the first case both eyes were affected, not one alone. In the other three cases blindness was not produced in the opposite eye. The condition was simply a diminution in the degree of visual power; and in one of these three both eyes were affected. The statement of Mauthner made in 1881 may, therefore, be repeated: "There is no case well authenticated in which lesion of one hemisphere has produced blindness in the opposite eye." The scheme of Grasset is thus seen to lack any basis in pathology. It need only be examined to convince one that it is artificial (Fig. 4).

4). The fibres from the two outer halves of both eyes are made to decussate twice; once in the corpora quadrigemina, and once in the corpus callosum. In this scheme a lesion situated in the internal capsule may produce crossed amblyopia, while a lesion in the occipital lobe will produce hemianopsia. It, therefore, explains all possible cases of blindness of cerebral origin, and is adequate to make clear any future cases of crossed amblyopia if such occur. The scheme of Graefe,<sup>1</sup> however (Fig. 3), not only explains all the facts yet established, but is simpler; and in it the course of the optic fibres is seen to be homologous to that of the motor fibres from the parietal region of the cortex to the spinal cord. Both decussate partially, and both bring

Fig. 4.



DECUSSATION OF OPTIC FIBRES. (According to Grasset.)

c, chiasm; C Q, corp. quadrigemina; C C, corpus callosum; C G, corp. geniculata; A, lesion in l. optic tract, and D, lesion in left hemisphere, producing right lateral hemianopsia; B, lesion in left internal capsule, producing right amblyopia.

First decussation in the chiasm.

Second decussation in the corp. quadrigemina.

Third decussation in the corp. callosum.

<sup>1</sup> Graefe, *Gazette Hebdomadaire*, 1860, p. 708.



each hemisphere into connection with both sides of the body. The scheme of Grasset has no such analogous fact to recommend it. Until new facts are brought forward, the scheme of Graefe is to be preferred therefore (Fig. 3).

It remains to examine the statements of Ferrier. His early experiments on dogs and monkeys led him to deny any functional relation between the occipital lobes and vision. To support this he cited thirteen cases in which lesion of the occipital lobes had not produced blindness.<sup>1</sup> Eleven of these cases were recorded prior to 1868 when accurate localization of a lesion in the brain was impossible. It is, therefore, not surprising that in a recent paper<sup>2</sup> he himself ignores these cases, and admits that subsequent experiments have proved his early statement to be wrong. He now holds that in the angular gyrus and occipital lobes are located the centres of sight. Of the four positive cases cited by him in 1878<sup>3</sup> to connect the angular gyrus with vision, one was without autopsy, as the patient recovered; two occurred in lunatics, and no exact determination of the limits of the field of vision were made; while the original report shows that the angular gyri *alone* were not involved, but the occipital lobes were also affected,<sup>4</sup> and the fourth is quoted from Bastian,<sup>5</sup> who ascribes the blindness to a lesion of the optic tract and corpora quadrigemina, and *not* to the lesion of the angular gyrus. Of the three positive cases cited in 1881<sup>6</sup> not one is accompanied by a record of autopsy. On the other hand, Ferrier himself gives thirteen cases in which lesion of the angular gyrus was not associated with any defect of vision. And Exner<sup>7</sup> cites twenty-two cases in which sight was not affected. How it is possible under these circumstances to affirm that the angular gyrus has any connection with sight is certainly incomprehensible. The result of physiological investigation on animals can only be accepted as true of man when confirmed by pathological observation. And in a question of this kind cases in man are perfectly worthless unless accompanied by a record of an autopsy, for it is only by a rigid comparison of ascertained limited lesions with symptoms that any conclusion can be reached. As Ferrier does not cite any such cases his conclusions must fall for lack of proof. The discovery of Wernicke, that a direct tract passes from the optic thalamus to the occipital lobe just beneath the angular gyrus, may explain the results of Ferrier. For a lesion of the angular gyrus, unless superficial, would probably involve this direct tract and thus produce a disturbance of vision.

<sup>1</sup> Localization of Brain Disease, 1878, pp. 124-130.

<sup>2</sup> Brain, Jan. 1881.

<sup>3</sup> Localization of Brain Disease, pp. 130-133.

<sup>4</sup> Fürstner, Arch. f. Psychiatrie, viii. and ix.

<sup>5</sup> Bastian, Paralysis from Brain Diseases, pp. 113.

<sup>6</sup> Brain, Jan. 1881.

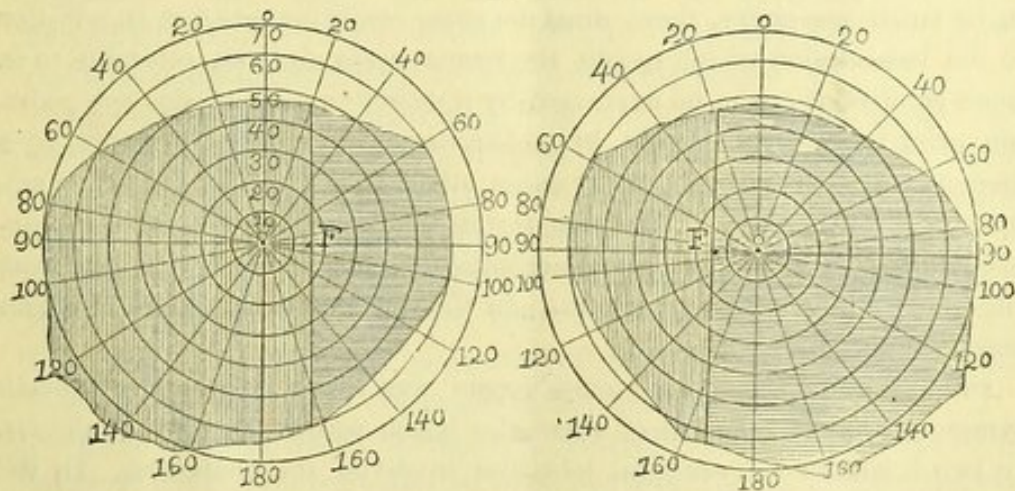
<sup>7</sup> Localization d. Gehirnk.

The statement based upon the study of the thirty-two cases here cited is, therefore, strengthened by the fact that opposing conclusions will not bear a strict examination. The visual area lies in the occipital lobes. It is not yet possible to connect definite areas of the cortex of one occipital lobe with definite areas of the retina, as Munk was able to do in the case of dogs and monkeys. Hemianopsia is produced in man whether the lesion lie on the convexity or on the median surface of the lobe.<sup>1</sup>

Any form of brain lesion, abscess, embolic softening, hemorrhage, tumours, chronic meningitis, if located in the course of the optic fibres or on the surface of one occipital lobe, may produce hemianopsia. The symptom is not due, therefore, to the shock of an apoplexy or embolism; nor to an increase of intracranial pressure; as cases occur in which neither of these conditions are present. It must, therefore, be regarded as a symptom indicating a local circumscribed lesion of one hemisphere, and not a general symptom (such as headache or coma) of brain-disease.

Before proceeding to consider the possibility of making a diagnosis of the location of the lesion in any given case it will be necessary to analyze the symptoms recorded in the cases here cited.

First. As to the symptom of hemianopsia it will be noted that in the majority of cases the hemianopsia was limited by a vertical line passing through the point of fixation. If the visual fields of the two eyes are

Fig. 5.<sup>2</sup>

VISUAL FIELD OF LEFT EYE. (After Förster). VISUAL FIELD OF RIGHT EYE. (After Förster.)  
*F* = Fixation-point; macula lutea. *O* = Entrance of optic nerve; the blind spot.  
 The vertical lines represent the defect of vision in left lateral hemianopsia. The horizontal lines represent the defects of vision in right hemianopsia.

compared in the figure it will be seen that the defect in the eye of the side opposite the lesion is much greater in extent than in the eye of the same side.

<sup>1</sup> Compare Cases II. 6, 18, with Cases II. 17, 19.

<sup>2</sup> The visual field is of course the reverse of the retinal area.

In right hemianopsia the right eye, and in left hemianopsia the left eye is most affected. It is, therefore, not to be wondered at that in cases of hemianopsia the patient rarely if ever notices the exact character of the symptom, and usually complains only of disturbance of vision in the eye most affected. It was by careful examination only that the nature of the disturbance was ascertained in the majority of the cases here cited. This fact is of great importance, for it follows that many cases of hemianopsia may escape detection, and that many cases of so-called crossed amblyopia might, if properly examined, prove to be hemianopsia. In proof of this I may refer to a number of cases<sup>1</sup> in which the lesion found was one which should have produced hemianopsia, but in which the report simply states that there was a disturbance of vision without describing its limit or character. Greater care in the examination of cases, and an exact determination of the visual field are necessary.

In all the cases reported here central vision was preserved. This was to be presupposed as only one-half of the macula lutea was affected. It agrees with the theoretical statement of Mauthner.<sup>2</sup>

In all cases, except those in which the nature of the lesion produced an increase of intracranial pressure, the ophthalmoscopic examination was negative.

It may, therefore, be stated that if in any case of hemianopsia the limit of vision passes beyond the fixation point, or if there is a diminution in the power of central vision, or if the visual field is diminished in extent in its entire periphery, there must be some condition present in addition to the local lesion which causes the hemianopsia and not referable to it. Such conditions are to be explained by a defective state of the eye existing prior to the hemianopsia, by an increased intracranial pressure, by a descending optic neuritis, or by some other cause. They are not symptoms of a local lesion. Mauthner states that colour-blindness in the unaffected halves of the eye never accompanies hemianopsia and one case cited here supports this statement. In the other cases no record of colour tests was given.

In eight cases here cited,<sup>3</sup> hemianopsia was the only permanent brain symptom present. In one of these the lesion was in the optic thalamus. In two it was in the occipital lobe, but involved the thalamus. In the remainder it was confined to the occipital lobe. These cases alone would prove the fact that the visual area of the brain is located in the occipital lobes; for the thalamus is to be considered only as a ganglion interposed in the course of the fibres to the cortex, and not as the seat of conscious perceptions of sight. Consciousness is associated with cortical

<sup>1</sup> Boston Med. and Surg. Journ., vol. lxii. p. 356; vol. lxxii. p. 100; vol. lxxxiv. p. 252; Archives of Medicine, Aug. 1882, p. 64; Brit. Med. Journ., Feb. 6, 1876.

<sup>2</sup> Mauthner, Vorträge aus der gesamt Gebiet der Augenheilkunde, vol. i. p. 360.

<sup>3</sup> Cases I. 1; II. 7, 18, 19, 22, 23, 26, 27.

activity only. Visual impressions received by the eye and sent inward as impulses to the brain are, therefore, perceived consciously only when they reach the cortex of the occipital lobes. In order to their perception the tracts to the cortex, and the cortex itself, must be intact. Destruction of other parts of the brain can be shown to have no effect upon vision if this region is uninjured. Hence the conclusion is inevitable that the visual area lies in the occipital region.

Secondly, as to the other symptoms. In thirteen of the cases here cited, permanent hemiplegia accompanied hemianopsia.<sup>1</sup> In all these cases except two,<sup>2</sup> this symptom finds its explanation in a lesion either of the motor tract between the cortex of the parietal region and the crus cerebri, or of the corpus striatum. In some cases one lesion was of sufficient extent to involve both the motor and the visual tracts, where they cross in the internal capsule. In the others the hemiplegia was due to an extension of the lesion from the occipital to the parietal cortex; or to a second lesion in the motor area. We have, therefore, no reason for referring the paralysis to the lesion of the occipital lobe.

The same statement applies to those cases, eight in number, in which hemianæsthesia was a permanent symptom.<sup>3</sup> In these cases a lesion in the optic thalamus, or in the posterior part of the internal capsule, or pressing upon these two parts was the cause of the symptom. The course of the sensory fibres in the brain above the level of the internal capsule is still unknown. The twenty cases of lesion of the occipital lobe without hemianæsthesia, however, furnish the important fact that the areas of common sensation do not lie in that part of the brain.

Aphasia, which was associated with right hemianopsia in ten cases,<sup>4</sup> was either due to an independent lesion involving the speech centre about the left Sylvian fissure, or to pressure upon the island of Reil by tumours, abscesses, or clots in the centrum ovale or the basal ganglia. It is conceivable that a tumour on the base of the brain might press upward into the Sylvian fissure, and inward upon the optic tract and thus in still a third manner produce this association of symptoms. The aphasia cannot, however, be referred to the lesion in the occipital region.

In the cases in which monoplegia occurred<sup>5</sup> there was always found a lesion of the central convolutions in the parietal region, and the unilateral convulsions or monospasms indicated even during life the seat of the lesion.

It is, therefore, evident that the symptoms other than visual cannot be referred to the lesion of the occipital lobes; and further that the visual symptoms cannot be referred to any lesion excepting to that of the occipital lobe. Therefore the visual area must lie in the occipital lobes.

<sup>1</sup> I. 2, 3, 4, 5; II. 1, 2, 4, 11, 14, 15, 17, 24, 25.    <sup>2</sup> I. 2; II. 25.

<sup>3</sup> I. 2, 3; II. 2, 4, 11, 13, 15.

<sup>5</sup> I. 3, 4, 5; II. 1, 2, 3, 5, 9, 13, 14.

<sup>4</sup> Cases II. 6, 10, 13, 20.

With these facts in view the question arises, are there any means of locating the lesion present in a case of hemianopsia? Reference is here made to lateral homonymous hemianopsia. All other forms are due to a lesion of the optic chiasm or optic nerve. A review of the cases and a comparison of symptoms with lesions will demonstrate that this is impossible. The lesion producing the hemianopsia may lie at any point in the course of the optic fibres from the chiasm to the occipital cortex, and in all cases the character of the hemianopsia may be the same.<sup>1</sup> It is only from a study of the accompanying symptoms, therefore, that the lesion can be located. But each of the other symptoms may be due to lesions situated at various points. If it can be proven from a study of the other symptoms that the lesion must be in one definite position, and at the same time a lesion in that position would intercept the visual tract, a probable diagnosis may be reached. For example: if a hemianopsia were associated with hemiplegia and hemianæsthesia of the like-named side, the lesion would probably lie in the internal capsule near the pulvinar of the optic thalamus where the visual and sensory-motor tracts intersect. Or if the hemianopsia were associated with paralysis of some of the cranial nerves to the ocular muscles, with loss of smell, or with anæsthesia of the face, the lesion would probably lie on the base of the brain and be producing destruction of the optic tract. In the latter case an atrophy of the optic nerves would follow in the course of time, and would be most noticeable in the eye opposite the lesion. Aside from these cases it would be impossible to locate the lesion, especially if it were one which gave rise to an increase of intracranial pressure. A number of diagnostic points proposed by Ferrier, by Wilbrand, and by Bellouard, when applied to the cases here cited were found to be worthless, and hence are not stated. The opinion expressed by Mauthner that there are no means of locating the lesion definitely must still be accepted.

The frequency of hemianopsia occurring with hemiplegia must not be estimated by the limited number of cases here cited. There are over two hundred cases recorded in the journals published during the past four years, but only those here given were accompanied by an autopsy. The affection is certainly more common than has been supposed, and as it frequently escapes the patient's notice, should always be sought for when a case of hemiplegia is examined. By careful examination of such cases it is probable that more accurate means of diagnosis may be discovered.

The limits of this article will not permit a discussion of the numerous cases on record in which inflammatory processes located in the visual area have given rise to visual hallucinations; or in which partial destruction of the cortex of the occipital lobes has produced a loss of memory of

<sup>1</sup> Ferrier's statement that in hemianopsia of cerebral, as distinguished from optic tract lesion, central vision is retained for several degrees on all sides of the point of fixation, is not supported by these cases.

objects recognized by sight—the interesting condition of psychical blindness, as distinguished from and not associated with actual blindness—or in which total destruction of both occipital lobes has been accompanied by actual blindness of both eyes. These facts unite in supporting the conclusion which has been reached in this article from the study of hemianopsia.

It is evident from a consideration of the facts here stated that anatomical research, physiological experiment, and pathological observation unite in assigning to the occipital lobes of the brain the function of sight. The right occipital lobe receives impressions from the right half of both eyes, and the left occipital lobe receives impressions from the left half of both eyes. The visual area of the brain lies in the occipital lobes.

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