"Histological Studies on Cerebral Localisation." By ALFRED W. CAMPBELL, M.D. Communicated by Professor C. S. SHERRINGTON, F.R.S. Received November 17,—Read December 3, 1903.

(Abstract.)

Introduction.

The essential aim of this work is to further the establishment of a correlation between physiological function and histological structure.

The present communication deals with the central gyri, the occipital, temporal and limbic lobes; but an account of the remainder of the cortex, viz., that of the frontal and parietal lobes and the insula, will be presented to the Society at a later date.

I.—*Material and Methods.*

The normally existent topographic variations in arrangement of cortical nerve cells and medullated nerve fibres have been adopted as a standard criterion in forming judgment on points bearing on localisation, and a thorough examination of the disposition of these elements over the entire cortex of a series of human and anthropoid apes' brains constitutes the groundwork of the research; but, in addition to this, pathological material has been employed to amplify and confirm points concerning the topographic distribution of special areas, suggested in the first place by the normal arrangement.

II.—*General Histological Considerations.*

After some general explanatory remarks on medullated fibre arrangement and cell lamination, each definable cortical area is discussed in turn.

III.—*The Pre-central or Motor Area.*

The pre-central or motor type of cortex is confined—roughly speaking—to the pre-central or ascending frontal convolution and a small coterminous portion of the paracentral lobule, its distinctive histological characters are a wealth of nerve fibres far superior to that of any other part of the cerebral cortex, and the presence of the "giant cells" of Betz or "ganglionic cells" of Bevan Lewis. It is important to notice that its structure differs absolutely from that of the post-central or ascending parietal gyrus.

On examining the brains of two chimpanzees and one orang it was found that a similar area could be mapped out, not only agreeing closely in point of structure and distribution with that in the human

brain, but coinciding absolutely with the field which Sherrington and Grünbaum have recently found responsive to unipolar faradization in the same animals.

Strong confirmatory evidence in support of the assumption that in man, as well as in the man-like ape, the elements controlling volitional muscular movements reside in this area, is afforded by an examination of the brain in cases of Amyotrophic Lateral Sclerosis, a disease limited in its attack to the motor system of neurones. In two such brains submitted to exhaustive examination a wholesale disappearance of the "giant cells" of Betz from the whole of their normal area of occupation has been disclosed. In the same brains the post-central gyrus entirely escaped affection.

Valuable material for the determination of differential localization in the motor field is afforded by the brains of individuals who have been disabled by amputation of one or other extremity, for in due course, either as a result of section of the nerve fibres with which they stand connected, or of suppression of the energy which they elaborate, the cortical "giant cells" controlling muscles in the amputated member undergo the change "réaction à distance" (Marinesco). In three cases of amputation of the leg and a like number of cases of amputation of the arm, in which the central convolutions were converted into serial microscopic sections, alterations were discovered limited in distribution to fields agreeing closely with Sherrington and Grünbaum's respective leg and arm areas in the ape.

The annectant gyrus or buttress at the level of the superior genu, relatively barren in "giant cells," seems to be an important guide to the point where the trunk area intervenes between those of the arm and leg.

IV.—*Post-central and Intermediate Post-central Areas.*

This area is readily defined in both man and the man-like ape, and is limited in its distribution to the post-central or ascending parietal gyrus and its paracentral annexe, the floor of the fissure of Rolando forming a definite anterior boundary.

Since its cortical structure differs markedly from that of the motor area, and at the same time exhibits features common to known sensory areas (the visual and auditory), its supposed motor function is denied, and it is maintained on the following additional grounds that it constitutes the terminus where fibres conveying common sensory impressions primarily impinge. Physiologically it is "silent" under the influence of electrical excitation, and also partial ablations give rise to no interference with movement (Sherrington and Grünbaum). Its fibres, like those of sensory spinal tracts, myelinate early (Flechsig and Vogt). It is the terminus for the "cortical lemniscus" (Tschermak).

Personal observations in three cases of Tabes Dorsalis, a disease affecting the sensory system of neurones essentially, have disclosed profound cortical alterations concentrated in this area. Similar observations in cases of amputation of an extremity have revealed changes situated on a corresponding surface level with those noted in the pre-central or motor area.

It is suggested that confusion concerning the function of the central gyri has arisen in the past, from the fact that the tracts of fibres pertaining to these gyri run in such close association below the Rolandic floor, that a lesion affecting the conduction chain of one gyrus is rarely free from the damaging influence of involvement of the other.

Intermediate Post-central Area.—This is a skirting zone in which the structural type is intermediate between that of the post-central area and the remaining parietal gyri.

It may serve for the transmutation and further elaboration of impressions primarily received in the post-central area.

V.—*Visual Area.*

Calcarine or Visuo-Sensory Area.—Two definite and distinct areas each possessing a specialised type of cortex can be mapped out in the occipital lobe. The distribution of the first is influenced by and bears an extremely close relation to the calcarine fissure; for the histologist its chief feature is the well-known line of Gennari.

Strong grounds exist for believing that this field is designed for the primary reception of visual sensations, and of these the following may be mentioned; the only fibres in the occipital lobe possessing a myelinic investment at the period of full fœtal maturation are those proceeding to this area (Flechsig); clinico-pathologists have proved that the minimal lesion equivalent to the production of a maximum of blindness is one concentrated in the calcarine region; it is possible to map out this area from changes in it occurring as a result of old-standing blindness (Bolton).

Occipital or Visuo-Psychic Area.—The second definable area forms an investing zone or skirt to the first, and a remarkable wealth of nerve fibres coupled with the presence of curious large pyramidal cells serve for its identification. It is argued that this cortex is specialised for the final elaboration and interpretation of sensations first received as crude impressions in the calcarine area, and that its destruction is responsible for those disabilities included in the category of psychic blindness.

In the chimpanzee and orang analogous areas can be demonstrated, but they extend much more widely on the lateral surface of the hemisphere.

VI.—*Temporal Lobe.*

Audito-Sensory Area.—The first important field is a small one occupying the transverse temporal gyri, and therefore concealed within the Sylvian fissure. As this is the first temporal cortex to become medullated, as it seems to be the terminus of the central auditory tract, and as there are clinico-pathological reasons for believing that its destruction is equivalent to the production of complete deafness, the assumption is favoured that it constitutes the primary auditory centre. But further evidence on this point is needed, and the results of the examination of the part in cases of congenital or long-standing deafness of peripheral origin would be welcome.

Audito-Psychic Area.—This area, of ready definition, covers the posterior three-fifths of the first temporal gyrus and is thus closely related to the one just mentioned. It is seen to correspond with the well-known centre for word-deafness, but in reference to that disability it must be indicated that the structure of this region is alike in the two hemispheres, and without denying the dominant psychic action of the area in the left hemisphere the opinion is expressed that the right side shares that function, because in the only recorded cases of complete, uncomplicated and irrecoverable word-deafness, verified by an autopsy—there are but two—a bilateral lesion has been discovered.

Similar areas are defined with equal readiness in the anthropoid brain.

Common Temporal Area.—The remainder of the temporal cortex shows a uniform type of structure stamped by a poverty in fibres and cells of large size, and it has been disappointing to discover that the angular gyrus is not endowed with any specialised arrangement.

VII.—*Limbic Lobe.*

Pyriform or Olfactory Area.—Histology supports comparative anatomy in suggesting that the lobus pyriformis must be regarded as the principal cortical centre, although not the sole one, governing the olfactory sense. Remarkable superficially-placed clusters of large stellate cells and a tendency on the part of the projection fibres to gain the surface, characterise its structure, and the rudimentary fissura rhinica forms a most definite limit.

Hippocampal Area and Cornu Ammonis.—The cortex covering the wall and lip of the fissura hippocampi differs from the above and also from that of the gyrus dentatus, but the function of this part remains obscure.

Limbic Area.—This practically covers the whole gyrus fornicatus. In the pregenual part deep chromophilous cells may be seen, resem-

bling ones found in the lobus pyriformis, and it seems likely that these are the end-stations for fibres proceeding from the inner olfactory root.

A total absence of large fibres and large cells and a simple plan of arrangement is the general character of this area and does not lend colour to the doctrine that it, and not the Rolandic region, is a centre for common sensation.

"On the Integrals of the Squares of Ellipsoidal Surface Harmonic Functions." By G. H. DARWIN, F.R.S., Plumian Professor and Fellow of Trinity College, Cambridge. Received December 2,—Read December 10, 1903.

(Abstract.)

This paper is a sequel to three others on ellipsoidal harmonic analysis and its applications, published in Series A of the 'Philosophical Transactions,' vol. 197, pp. 461—557; vol. 198, pp. 301—331; and vol. 200, pp. 251—314.

The integrals referred to in the title are absolutely essential for practical applications of this method of analysis. A table of all such integrals is given in the first of the above-named papers, but the results are only approximate. In the present paper the rigorous forms of the integrals, numbering $1+3+5+7$, are given for the surface harmonics of orders 0, 1, 2, 3.

A mistake is detected on p. 556 of the first of the previous papers, where the coefficient of β in the cosine-function of the third zonal harmonic is erroneously given as 3; it should have been $\frac{5}{2}$.