B

Mr. G. J. Bertram's

Thesis

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Accompanied by a
box of Microscopical Specimens.
and a box of Wet Preparations.

Functions of the Cortex Cerebri - with Investigations.

List of Preparations.

№ 1. Injected Brain of Sheep.

2. Longitudinal Section of Sheep's Brain, Showing parts in median line, also Convolutions.

3. Cyst of Cœnurus Cerebralis.

4. Dissection to Show Rete Mirabile. Jacobson's organ also Shown.

5. Portion of Calvarium from a Sheep, the part within the circle of ink Showing Commencing absorption by Cyst.

6. Wall of Cyst removed by operation.

7. Calvarium, Showing opening through which cyst Extracted.

8. Jar Containing 7 Brains - numbered.

Introductory Remarks.

Amidst the general advance which has marked the History of Medical Science during late years, it is satisfactory to note the real progress that has been made in our knowledge of the Nervous System. This is entirely due to the fact that it has attracted to itself the labours of many of the best observers in all countries, a circumstance not to be wondered at when we consider that the interest which attaches to the study of this System cannot be surpassed either in a Physiological or Pathological point of view. How can it be otherwise? Not only is it the Instrument and Expositor of the Mind, and the medium by which we hold communion with the world around us, but it is also the Excitatory Centre which induces motion in all the tissues, thus maintaining that mysterious molecular movement which we call Nutrition, and which is the Essence of Life. It is in short through it we move and live and have our being. A System charged with such high duties, such grand Physiological problems must of necessity present itself as an attractive study. No doubt many of our present theories and conclusions will undergo modifications before

they are finally settled, but notwithstanding, there is a great deal in the Physiology and Pathology of the Cerebro-Spinal axis that is fairly made out and well understood, and we may confidently hope that much that is now obscure will gradually reveal itself, and become clear to our understanding.

No better instance of the Scientific advance alluded to above could be given than the establishment of the theory of Reflex action. Although this important function of Nervous Centres was recognised dimly by older observers as Whytt and Procaska, it was not till 1832 that it was independently discovered by Marshall Hall, and it was by means of his untiring labours that the new doctrine was spread and became very generally accepted. Since that time much important work has been done. We have had Flourens's remarkable book, Longet's great work, and the researches of Schiff, Brown-Séquard and others, all of which contain most valuable facts and suggestions, and these, by enlarging our knowledge of the Nervous System, have paved the way for many of the more recent enquiries.

Chief among these enquiries is the now keenly debated question of the Localisation of Brain Function, which has been taken up with great eagerness since 1870, when Fritsch & Hitzig made their somewhat startling announcement that the generally believed notion of the Brain not being excitable was an erroneous one. According to the present theory of Localisation of Brain Function, individual Convolutions are looked on almost as distinct organs, each of which is endowed with special properties and functions. The idea is by no means a new one: it is only the recent methods of investigations with their results which have given a new aspect to the question. Thus, former years saw the promulgation of the Phrenological System of Gall & Spurzheim, which excited great interest in its day; and that it exercised no small influence for a time is shown by the general and comprehensive character which this Localisation of Function assumed, being extended to every department. An example of this is seen in that curious book published by Benjamin Ridge, M. D. and entitled "Ourselves, our Food, and our Physic", in which the learned Doctor announced to the Scientific world that he had

long since discovered "that some of the most important organs of the body had a local position on the Tongue, and that whenever any distinctive disease occurred in them, the corresponding portion of the Tongue pointed it out." To this new system was given the dignified title of "Glossology" or "The Laws of the Fouling and Cleaning of the Tongue," and we find this important organ divided into Six Tracts, each Tract being double and occupying a similar part on each longitudinal half of the Tongue. Thus we have the Respiratory Tract, the Kidney Tract, the Brain Tract, and so on! Such attempts to take Science by storm soon end in failure, for they are founded only on the imagination of their authors, who have dispensed with the only sure though slow method by which real progress is made, viz. the Inductive Method, in which facts are observed and accumulated & Conclusions drawn therefrom.

In the present day, however, the question of Localisation of Brain Function has been undertaken in the most thorough Spirit of Enquiry, & besides treating the ~~facts~~ matter from a Physiological, Pathological, and Anatomical point of view, the field of Experimental Research has been entered on by

some of the most acute observers and thinkers of the present day.

In this Thesis we propose to give a short historical sketch of this matter of Localisation of Brain function, then to state in as comprehensive and succinct a manner as we can the present state of knowledge on the subject, and in conclusion to make a small contribution, furnished by the Domain of Pathology, which we venture to think bears upon some of the points raised in this matter and which are still "sub judice."

Historical Sketch of our Subject.

Before the time of Galen we find all knowledge of the nervous system vague & uncertain, such men even as Plato and Aristotle being unable to agree as to whether the Soul or Vitality had its seat in the Head or not. They, as well as Hippocrates, had no knowledge of the Nerves, though the successors of Hippocrates at Alexandria distinguished between those that were Motor and those that were Sensory, and they considered there was sufficient evidence to fix the Cerebellum as the seat of the Soul or Vitality.

With Galen himself came new theories & fresh inductions. Regarding the Soul as a material body, he thought that it resided in one of the Ventricles of the Brain, though he could not make up his mind as to which Ventricle it was, and to the Brain itself he assigned the Functions of Motion, Sensation, Imagination, Reason and Memory. In addition, however, to this Galen undoubtedly recognised the two important facts, first, that the Brain was the source of all the power that the Nerves have, a constant supply of "Animal Spirits" being propagated from it, and, secondly, that pressure on certain parts of the Brain abrogated Motion, and Sensation, inducing "Sopor."

Posseidonius, who came after Galen, devoted his attention to the Study of Cerebral function, and from his observations and researches he concluded that the Anterior part of the Brain was the seat of Imagination, the middle part of Reason, and the occipital part of Memory. These were the views very generally held for some time, and with the addition proposed by Nemesius, that the Anterior part of the Brain was the seat of Sensation as well as of Imagination,

they were the opinions handed down from
generation to generation and were the ones in
vogue during the middle ages.
Of course they received modifications and ad-
-ditions to a slight degree as they passed
from Century to Century. Thus William of Soli-
-ceto, who flourished about the time of our
Edward i, Extended somewhat the Localisation
of the Brain Functions. According to him Per-
-ception occupied the Anterior half of the
first Ventricle, and Imagination its Posterior
half, while the Middle and Posterior Ventri-
-cles were occupied respectively by Judgment
and Memory. And here we may observe that
the writers of this period seemed to employ
the term Ventricle to signify the different
portions of the Brain, and not in order sense
of a small cavity.
It was reserved for Lanfranchi, a pupil of So-
-liceto, to propound views, which must wear
an amusing aspect to readers of the present
day. Thus, he gravely states that the middle
portion of the Brain is Funnel-shaped, so as to
receive impressions better, and he further consi-
-dered that the masses of Nervous matter known

to us by the name of the "Nates" were so placed that the Ventricles might use them as Seats or cushions to repose upon when it pondered over matters of the Fancy!

We will not dwell further on these odd notions and fancies, but have the sort of feeling that, as the practitioners of those days took them as guides in their treatment of cases, it is as well they carried their generalisations no further. Though of no value to us in a Scientific point of view, yet they are instructive and of interest. To recall them, however briefly, brings before us the thoughts and fancies of our predecessors, and bridges over that long interval of time which separates us from the Fathers of the Healing Art. We will see also as we continue our historical Sketch that many of these older fancies & beliefs do not differ much from the pretentious attempts of more modern times, and that with all our advancement and knowledge we sometimes seem not to be much in advance of the efforts of those who lived in less enlightened days.

Our next reference must be to Bonnet, who seems from the quotation attributed to him in Bateman's

Book on Aphasia, to have surpassed even the theorists of the present day in his views. "Every Faculty," says he, "Sensitive, Moral, or Intellectual, is in the Brain connected to a bundle of fibres; every Faculty has its own laws, which subordinate it to other Faculties, and determines its mode of action; and not only has every Faculty its fasciculus of fibres, but every word has its own fibre." Such a statement as the above had no foundation in the Anatomical Knowledge of the Speaker, and was on an Equality with the Equally Imaginative System of Gall and Spurzheim, which so recently roused popular Enthusiasm. No doubt there was a good deal of truth in many of the arguments adduced by the Supporters of Phrenology. Thus no one denies such facts as that other great Physiological operations have their work apportioned to special organs, such as the Stomach, Liver &c, Each of which performs a peculiar office in the Assimilation of food; or that no two individuals are alike in propensities, talents, or other mental faculties; or that in the Insane alterations in one or more of the

Mental faculties is vastly more frequent than in all of them together; or that during Dreams some faculties are awake while others sleep. All these instances, and others that could be enumerated, are to our mind perfectly legitimate arguments in favour of the Plurality of Cerebral organs; but they do not justify us in founding a System in which the Development of the various mental powers is judged of by an Examination of the Cranium, and in which there are ascribed to certain prominences existing only on the External Surface of the Skull propensities and Crimes that do not exist in nature but are the growth of Society. As it has been well put:- "What would the organ of Theft effect if there were no Property, or the organ of Drunkenness if there were no Spirituous liquors, or the organ of Ambition if there were no Society?" It is not to be wondered at that a System should soon collapse, which, instead of gathering the moral characters of individuals from their daily walk or behaviour, and their intellectual capacity from their conversation or writings, relied for the information on the inequa-

-lities on the skull, ~~for the information~~, presuming the inequalities exist also on the surface of the Brain.

As we proceed with this sketch we will see how much the Faculty of Language has attracted attention in this question of Localization of Function, and it occupied a prominent place in the Phrenological System. Gall not only placed it in those Convolutions that rest on the Posterior part of the Supra-orbital plate, but he went further than this, and declared that there were 2 organs for Language in each Hemisphere, one originating the idea of Words, the other a talent for Philology and the Spirit of Language. Spurzheim did not quite follow his colleague in this view as he contended that there was only one organ of Language, and that it lay transversely on the Posterior portion of the Supra-orbital plate. In the year 1825 Bouillaud pointed out how frequently loss of Speech coincided with lesion of the Anterior lobes of the Brain, and eleven years after this Dax carried the Localization still further by bringing forward cases to prove that the Faculty of

Language is stated only in the left Anterior Lobe. About the same time Taddei de Gravina published some observations which were not very happy in their Localisation, but they show how much interest the subject was a-rousing, and we find other authors as Lallemand, Fabre, and Cruveilhier contributing to the Literature of the Subject and bringing forward cases in support of their opinions. As yet only Clinical observations had been made bearing on the matter, but we now find the results of Experimental Physiology adduced, and for a long time they settled the question. They seemed to show conclusively that the Brain was insensible to all Stimuli, Mechanical, Chemical, or Electrical. It is true that Haller and Zinn had obtained Convulsive movements by plunging instruments into the medulla of the Cerebrum, but it was very generally held, and with good reason, that these effects were due to injury of the deeper parts. Hence when the experiments of Flourens, Longet, Magendie, and others always produced negative results, they were looked on as decisive in the matter.

Probably the Experiments of Flourens as much as anything else carried Conviction to the minds of all, for he showed that the gradual slicing away of the Brain was possible within certain limits. What was left of the organ seemed able to carry on all the functions of Life. It was only when the removal was continued that gradual enfeeblement & ultimate loss of all the Functions ensued, and intelligence and volition seemed to be entirely lost. As a consequence of these experiments Flourens not only decided in favour of the Non-excitability of the Brain and of the Non-localisation of Function, but he also promulgated another view. Regarding the Cerebrum as acting in its entirety he considered he was justified in stating a Law of Interchange or Vicarious Function, according to which all portions of the Brain, besides fulfilling the same functions were able to supplement each other in case one or several of them were destroyed. It was thus Flourens met a difficulty which has presented itself in the Experiments of later investigators and which will hereafter come under our consideration, we refer to the transitory character of many of the effects produced or following the Experiments.

For many years the Subject was looked on as quite settled by Flourens's Experiments and all acquiesced in the Conclusions arrived at. This unanimity of opinion was only interrupted now and again by the expression of opinion on the part of some individual observer, who had met with facts in the domain of Pathology which it was hard to reconcile with the commonly received views. Thus in 1861 the matter of Cerebral Localisation was brought into notice again, especially with reference to the affection "Aphasia", by the announcement of Broca that not only does Aphasia generally accompany Left Hemiplegia but that it is commonly associated with a lesion of the surface of the Third Left Frontal Convolution.

In our own country two or three years after this that very able and original thinker Hughlings Jackson published his observations on the Subject of Unilateral Convulsions beginning in one or more Muscular groups and then extending to others. He considered that these must be due to lesions of the Cerebrum and probably to lesions of the Convolutions. We have only to refer to his papers on the Subject of "Partial Convulsion

from Brain Disease" to see that this was his idea as early as 1866. In fact we believe that it was the publication of Hughlings Jackson's paper on the "Study of Convulsions" that led Ferrier to institute his well-known Experiments, which were published in 1873, and to which reference will be again made, but which we may here state, by reason of their extent and accuracy not only corroborated the results of Fritsch and Hitzig, but have tended to unsettle all the old ideas of Cerebral Physiology. Too much credit cannot be given to Hughlings Jackson in this question, for, relying solely on Clinical facts and observations, he generalised the whole subject of Localisation of Brain Functions, and made applicable to the whole organ a theory which as yet had only been assigned to certain portions. In the whole range of literature on the subject of Nervous diseases no writings surpass his for originality and closeness of reasoning, and in them we find anticipated many of the Experimental results of later investigators. In fact we must assign to them the chief credit of having awakened general interest in this question of Localisation. And they seem to have done this abroad as

St. Andrews Medical Graduates Transactions Vol iii. 1870

well as at home, for in 1866 we find Vulpian deeming it necessary to go fully into the subject in his review of our knowledge of Brain Physiology. He then pronounced unfavourably against the idea of Localisation, declaring that it had been by no means proved or demonstrated. To ascertain what was the view at home on this subject a few years ago we have only to refer to the work of Dr Carpenter, one of our most distinguished writers on Physiology, and we will find the same verdict pronounced there. Thus he speaks as follows:- "The Anatomical relations of the Cerebrum to the other Encephalic Centres clearly demonstrate that it is not one of the Essential or fundamental portions of the Nervous System, but a superadded organ, receiving all its impulses to action from the part below, and operating on the body at large through them." There were more definite views held in reference to other parts of the Brain, for the Corpus Striatum was considered to have Motor power and the Optic Thalamus Sensory function. Further, the Corpora Quadrigemina were looked on as the principal Nervous Centres for the Sense of Sight and the movements of the Iris, and the

Leçons sur la Phys. du Système Nerveux. 1866.

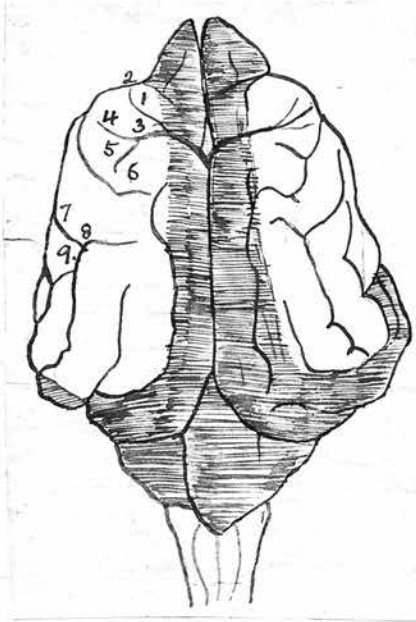
Carpenter's Physiology. 7th Edit. p. 641.

office of the Cerebellum was held to regulate and combine Muscular movements. But the only general idea about the Cerebral Hemi-spheres was that in some mysterious way they were the Seat of the Mind. Composed of masses of Ganglionic Cells and Nerve-fibres, placed above the Basal Ganglia, and capable in every part of the same function, they were considered to have an indefinable power of controlling these Ganglia at their Base, either in Conse-quence of impressions received from the Peri-pheral parts, or under the dictates of the Will, and so to produce those delicately balanced and harmonious movements of Groups of Muscles, many of them very different and antagonistic in their action.

A few short years, however, were to see these opin-ions called in question. Hitzig having observed that the application of a Constant Galvanic current through the Posterior part of the head caused movements of the Eyes in man, he in Con-junction with Fritsch ~~and~~ pursued further inquiries, and in 1870 they published their Experi-ments which seemed to show conclusively that the Cortical surface of the Brain was responsive to

Electrical Stimulation at certain spots, and that definite Muscular movements followed the application of the Electrodes to certain definite areas. It was at once evident that unless these facts could be explained in some way that the old views must be abandoned, and that we had entered on a new era in which the guiding principle was to be that the Cortical Surface of the Brain no longer acted in its Entirety, but that definite Muscular movements are connected with definite areas on the surface of the Convolutions of the Cerebrum.

This closes our Sketch of the history of this Subject, and we will next have to pass on to the numerous Series of investigations which this discovery of Fritsch and Hitzig have opened up. We will state them as shortly and as clearly as we can, but they extend to a large number, for the question has been keenly debated, and is by no means settled, and we are correct in saying that the new doctrines have to do vigorous battle to maintain their ground, for the old Cherished beliefs of our fathers, their accepted theories and opinions ~~have~~ are not being relinquished without a Struggle.



1 = Flexion of head on neck, in median line.

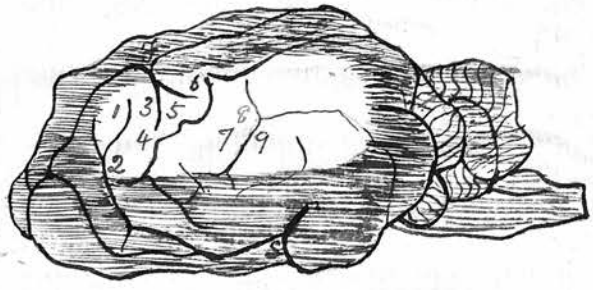
2 = Flexion of head on neck with rotation to side of stimulus

3+4 Flexion of Ant. Limb.

5+6 Flexion of Post. Limb.

7.8.9: Contraction of orbicularis oculi & other facial muscles.

Brain of Dog - view from above.



Brain of Dog - profile view. Figures as above.

The unshaded part is that exposed by opening in Skull.

In Considering this part of our Subject we have thought that it would be rendered clearer by bringing together into Groups the different series of Experiments and observations, and following this plan we propose to make 3 Groups, taking them in the order in which they stand below:—

i Investigations by Local Irritation.

ii Investigations by Local Destruction.

iii Any observations in Comparative Anatomy, Anatomy, Histology, and Pathology, bearing on the Subject.

Of the Investigations by Local Irritation those of Fritsch and Hitzig were the first. They were published in 1870 and they demonstrated the excitability by Electricity of certain Spots on the Hemispheres of the Brain. As a result of their Experiments Fritsch and Hitzig pointed out that one portion of the Convexity of the Cerebrum in the Dog is Motor and another Non-motor, the former lying Anteriorly, and containing separate Centres for the Anterior and Posterior Limbs, for the Muscles of the Trunk, and for the Muscles of the Face. In all of these Experiments Dogs were used, and the Constant Current was employed. Fritsch and Hitzig seem to have felt

Reichert's Archiv. 1870 p. 300.

that the results might be attributed to Conduction, for they adduced the following reasons as disproving this view: —

1. The feebleness of the current used.
2. The close approximation of the Electrodes.
3. The bad Conductivity of Brain Substance.
4. The occurrence of the Contractions on the opposite side of the body.
5. The non-appearance of the movements on slightly shifting the Electrodes.

Three years after this, in our own Country, Ferrier, influenced greatly by Hughlings-Jackson's theory of Epileptic discharges, took up the subject of Brain Localisation. He experimented on the Brains of different animals, as cats, dogs, and rabbits, and he employed the Faradic current. He defined various Centres from which movements of the limbs, face, mouth, tongue, eyes, ears, &c, could be definitely & distinctly excited. On the whole he confirmed the experiments of Hitzig. West Riding Asylum Reports Vol ii 1873.

In this year, 1873, Hitzig made a second series of experiments and from them he believed he was able to establish the existence of a distinct Centre for the several movements of the Eyes. Reichert's Archiv. 1873. p. 397.

Coinciding with a part of the Facial Centre, and especially that part which affords Nervous supply to the Protective Muscles of the Eye. He thought that Ferrier's results were vitiated by diffusion of Currents and that he had made his Motor region too extensive.

On the whole there is no great or essential disagreement between Hitzig and Ferrier as to the position of their Centres, the chief difference arising apparently from the fact that Hitzig using the Constant Current finds a smaller extent of Convolution electrically excitable than Ferrier does with the Faradic Current, and as a consequence he claims the existence of fewer Centres than Ferrier does.

In the experiments made by the New York Society of Neurology and Electrology, including Drs Dalton, Arnold, Beard, Flint, and Mason, results confirmatory of Hitzig's observations were met with. This Committee also selected Dogs, for the experiments are most easily performed on them, owing to the large size of the cerebrum, and the comparatively little injury suffered from haemorrhage. The animals were Etherized and kept more or less under the influence of

New York Medical Journal March 1875. p225

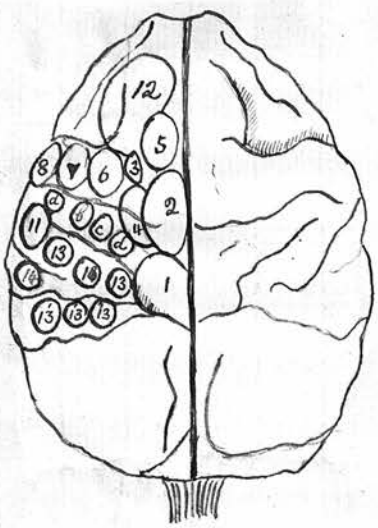
the anaesthetic the whole time. The Stimulus employed was a weak Galvanic current from a Battery of 8-16 cells, and the experiments were made with every care and nicety. The Electrodes were rounded Platinum points, fixed at a distance of one Millimetre apart. They were applied to the Cerebrum in such a manner as not to wound but only to touch it, and were held in Contact with the Brain for about one Second only at each application. The applications were repeated at short intervals at the same Spot for from 10 to 40 times in Succession in order to make sure that the reactions obtained were not accidental. The Cortex corresponded in all essential particulars with those discovered by Hitzig, and were nearly, though not quite, uniform in location on both sides of the Brain and in different animals. In all the experiments Crossed action was generally observed.

Both Hitzig and Ferrier have extended their observations to the Brains of Monkeys, and in them Hitzig found that the Anterior Cerebral Convolution constitutes the true Motor part of the B Cortex of the Cerebrum, the several Centres

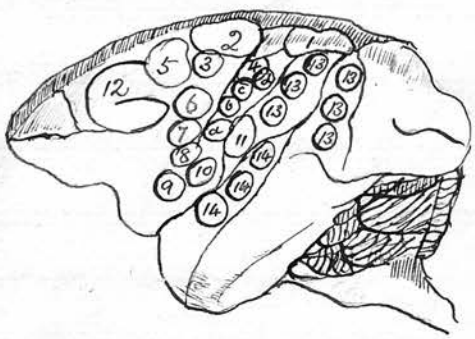
lying in it from the Median Fissure downwards to the Slyvian Fissure. He further maintained that about 3 millimetres from the median line is the Centre for the Posterior Extremity of the opposite side, and about 3 millimetres further outwards that for the Anterior Extremity. Seven millimetres beyond this laterally is the Centre for a part of the muscles associated with the Visual organs, and close to the Slyvian fissure is a fourth Centre governing the muscles of the Mouth, Tongue, and Jaw of both sides. Weak currents applied to the Parietal & Frontal regions were not followed by any movements.

In a still more recent Communication Hitzig states that he has found that lesion of the Occipital or Posterior Convolutions of the Cerebral Hemispheres produces Blindness of the opposite eye and paralytic dilatation of the corresponding Pupil. Centralblatt f. d. Med. Wiss. 1874. p. 548.

As the result of his observations on the Brains of Monkeys, Ferrier has mapped out the following regions, the stimulation of which gives results which may be condensed as follows from his new work entitled the "Functions of the Brain": — Proc. Roy. Soc. No 161. 1875. also Functions of the Brain p. 141.



Upper surface of Brain of Monkey.



Left side of Brain of Monkey.

(1) Advance of the opposite hind limb as in walking
(2) Complex movements of the thigh, leg, & foot.
(3) Movements of the tail.
(4) Retraction with adduction of the opposite arm.
(5) Extension forward of the opposite hand and arm.
(6) Supination and flexion of the fore-arm.
(7) Action of the Zygomatics.
(8) Elevation of Ala of Nose and upper lip.
(9) Opening of mouth with protrusion of tongue.
(10) Retraction of Tongue.
(11) Retraction of opposite angle of mouth.
(12) Eyes open widely; pupils dilate; head & eyes turn to opposite side.
(13) Movement of Eyes to opposite side with an upward or downward deviation: contraction of pupils.
(14) Pricking of opposite ear; head and eyes turn to opposite side, and pupils dilate widely.
(15) Torsion of lip and nostril on the same side.

No results followed the Stimulation of the Anterio. frontal and Occipital regions; nor did the Island of Reil react to Stimulation, while application of the Electrodes to the Corpora Striata caused Tonic Spasm of the whole of the Muscles of the opposite side, and consequently a Condition of Pleurosthotonos. Stimulation of the Optic Thalamus was Negative.

In a further series of Experiments Ferrier claims to have localised the regions of Special Sense, such as those for Sight, Hearing, Touch, Smell, Taste, and Organic Sensation; but as these experiments come into our group of Investigations by Local Destruction we will not further allude to them now.

Experiments on Brain of Monkeys, Second Series, read before the Royal Society May 13. 1875.

It would appear, however, that it is not only Groups of Striped Muscles that can be thus functionally connected with definite regions of the Cortex Cerebri. The Experiments of Lépine and of others make it probable that the Heart, the Blood-vessels, the Spleen, the Intestines, and the Salivary Glands can be brought into a similar functional connection with definite regions of the Cortex. Thus Lépine found that irritation of the Post-frontal Convolution in a curarised Dog caused a rise of Blood tension in the Crural artery of 7 Centimetres of Mercury, accompanied by an increased number of beats of the heart. Lépine also observed that if irritation be applied to a spot, which in an uncurarised Dog, would cause movements of one of the opposite feet, the Temperature of this foot rises several tenths of a Degree. The

Gazette Medicale 1875 N° 25.

Gazette Medicale 1875. N° 52.

temperature of the foot on the same side rises also, but to a less degree, while that of the Rectum remains Stationary. Another Experimenter, Poche fontaine found 4 Spots on the Cortex irritation of which caused contraction of the Spleen, and 6 Spots from which movements of the Intestines could be produced.

We will only refer to one more set of Experiments undertaken to test the value of those of Hitzig and Ferrier, and these were performed by MM. Carville and Duret. In their first Series of Experiments they were unable to obtain any Electrical excitability of the Cortical Substance of the Hemispheres, but they were more successful in a later Series, and they seem to have established that Electrical irritation of the Cortex has a certain local action, and that the result of this action varies with the points of application of the Electrodes. They consider, however, that the movements are really due to diffusion of the currents, and, Speaking Generally, they state that Ferrier's irritable Zone is too great & that a mean between his & Hitzig's is the proper Zone. In this view they are supported by M. Dupuy.

Examen de quelques points de la Physiologie du cerveau 1873.

Up to this point the Investigations by Local irritation have been undertaken entirely to determine whether or not Electrical Stimulation of certain areas would cause movements, but the experiments of Braun, Burdon-Sanderson, Hermann, and Putnam, to which reference will now be made, were done more with the view to Elucidate and establish the "modus operandi" of the Stimulation.

In Braun's experiments points were found upon the Cerebral Convolutions which produced, under the application of the Electric Stimulus, the usual definite Muscular Contractions. A horizontal section was then made at a depth of 1 or 2 millimetres beneath the surface, leaving the flap in place but cutting off the Anatomical Continuity of the Brain tissue. The irritation being then reapplied to the original spot, failed to excite any Muscular contraction; but if the flap was turned up and the Electrodes applied to the cut surface beneath, a current of Similar or slightly increased strength again produced the same movements as before. Repeated trials of this kind yielded the same results.

Eckhardt's Beiträge zur Anatomie und Physiologie, Band VII.

Putnam verified these results by similar experiments, the only difference being that he found it necessary to increase only slightly the current's intensity in order to produce the same muscular movements as before. Boston Medical ~~Journal~~ & Surgical Journal Vol. 91.

In the course of some experiments that he conducted Hermann observed that destruction of the Centres by drying, or by Nitric or Acetic Acids, did not prevent the irritation of the Electric Stimulus from producing the usual Effects, & that even after mechanical Removal of the Centre, as by the Actual Cautery, irritation of the underlying Brain-Substance still called forth the same movements. Hermann concluded from these facts that, Since the phenomena of motion are produced after the Surface has been destroyed, we must assume Conduction of the Current to a Deeper Centre, and that, therefore, the necessity for believing in a Superficial Centre is done away with. Pflüger's Archiv. Band 10.

Soltmann made some observations of great interest on Puppies, in which he found that irritation of the Cortex Cerebri before they were 9 days old produced no Muscular Contractions or Movements; and extending his obser- Centralblatt f. d. med. Wiss. 1875 p. 209.

-vations to young animals he detected a matter of no small importance, viz. that in them the Centres differ in Size and also in Shape from those of Adults.

We will Conclude this Group of investigations by noticing those of Burdon-Sanderson. His first Step was to produce some of the most characteristic movements in a cat, and then to localise the Centres, which were found to correspond exactly with Ferrier's results. He then severed the parts containing the "Active Spots" by means of a thin knife, without dislocation of the flap from the deeper parts: the same results were produced ~~as before~~ when the Centres were irritated as before the incision was made. He next found that if the incision was made at a level somewhat lower than in the preceding experiment, this was not the case, and when the flap was removed Spots were found on the cut surface with the same topographical arrangement, by irritation of which movements were produced as in the case of the superficial Centres. Further, by a horizontal incision 10 or 12 millimetres deep, the upper and outer part of the Corpus Callo-

Proceed. Roy. Soc. 1873.

-sum was reached. Excitation of this part produced still more distinctly the characteristic movements, the relation of the "Active Spots" remaining strictly the same. According to this the Specific Motor powers do not reside absolutely in the Grey matter of the Convolutions, but in each case similar effects may be produced by exciting, after successive removals, each successive fresh surface of that wedge of Brain substance of which the Base corresponds to the particular superficial Motor area and the Apex to a point in the Corpus Striatum. Burdon-Sanderson thinks the movements are most distinct when the Irritation is effected directly on the Corpus Striatum.

Investigations by Local Destruction.

In this class of experiments the part of the Cortex whose function is to be studied is destroyed, and it is then observed what Muscles become incapable of Voluntary movement. The Destruction is accomplished in various ways. Thus we find Nothnagel cauterising small portions of the Cineritious substance by means of injections of Chromic Acid; Goltz washing

away the Cerebral matter by means of a stream of water directed through the opening made by a Trephine; and Ferrier destroying the Brain matter with the Actual Cautery.

We think that Fournie with his injections into the Brain of a few minims of a strong solution of Chloride of Zinc was the pioneer in this class of investigations. The results were, however, vitiated by the diffusion of the irritant, and by the subsequent inflammatory symptoms that arose and complicated the case. The same must be said of the injection experiments with Chromic Acid carried out by Nothnagel, which are open to the same objections.

Recherces Experimentales Sure le fonctionnement du Cerveau. Paris 1873.

Virchow's Archiv. Bd. 57. p. 184, and Bd. 58 p. 420.

Subsequent investigators, accordingly, abandoned this injection plan, and have adopted methods for the removal of the Cortical centres in which the effects can be localised.

Hitzig operated on a dog by scooping out the Grey matter from regions previously defined by Electrical Stimulation. After removal of the Grey matter of the Posterior division of the Gyrus there was impaired motility of the limbs and deficient co-ordinating power

Untersuchungen in das Gehirn p. 89.

of the affected muscles, due, according to Hitzig," to a loss of "Muscle-Consciousness."

Ferrier in his last Series of Experiments on the Brains of Monkeys used the Actual Cautery for destroying the Brain substance. He applied this method both to the Motor & Sensory Centres, as defined by Electrical Stimulation. Destruction of the Motor Centres gave corresponding Paralysis. In most cases death happened a few days after the operation; yet during this time the Paralysis got worse, there being no evidence of any compensatory action of other parts of the Brain. The Paralysis seemed to be one of Motion only, Sensation in every form being perfect. As regards the Sensory Centres, Destruction of the Angular Gyrus caused Blindness of the opposite eye, and removal of the Temporo-Sphenoidal Convolution abolished the Sense of Hearing. This method showed also that the Hippocampus Major and the Hippocampal Convolution are connected with the Sense of Touch on the opposite side of the body; the Gubernaculum Cornu Ammonis or tip of the Uncinate Convolution with the Sense of Smell on the

Experiments on Brains of Monkeys, read Before Roy. Soc. May 13. 1875.

same side of the body; the lower part of the Tempero-Sphenoidal lobe with the sense of Taste; and the Optic Thalamus with Organic Sensation on the opposite side of the body. No very definite results followed the attempts to ascertain the functions of the parts of the Brain which do not react to Stimulation.

In a Dog in which Schiff removed the Motor Centres of the Anterior Lobe, after it had recovered from the effects of the operation, the ultimate result was impairment of the power of the limbs, resembling the condition of Locomotor Ataxia. Yet we find Dupuy removing the whole of the upper surface of one Cerebral Hemisphere in a Dog without any apparent impairment of the Muscular power. Lezioni di Fisiologia Sperimentale &c. Firenze 1873.

Examen de quelques points de la Physiologie du cerveau 1873.

Carville and Duret obtained the same results as Dupuy did; for they invariably found that, though the removal of the Grey matter corresponding to the Motor Centres was followed by a certain amount of Muscular weakness, still it was generally recovered from. Three in one Dog on which they operated Archives de Phys. 1875 p. 352

removing the Grey matter corresponding to the Motor Centres for the limbs, there was inability to fully extend the paws, and consequently the animal walked on the dorsum of the foot. This abnormality, at first constant, was afterwards intermittent, & finally disappeared about five or six days after the operation.

By means of a cork-borer Hermann removed from Dogs Cerebral areas, Stimulation of which gave localised movements, & found that the Paralysis and loss of Sensation which immediately followed the operation wholly disappeared after some days. Pflüger's Archiv X. 77.

Soltmann confirmed by the method of local destruction his experiments with Electricity, which turn on the varying importance of the Cortex at different ages and which seemed to show that before a certain age the areas in the Cortex do not exist. He found that destruction of the Cortical Centres in Rabbits and Dogs produced no Symptoms of Paralysis or Ataxia during the first ten days of their life.

Vulpian removed the right Sigmoid Gyrus Leçons sur l'appareil vaso-moteur 1874-1875. vol II

in a dog. The chief results were partial Paralysis improving with time, Epileptiform phenomena due to Encephalitis, and a tendency to right rotation.

Brown-Séquard cauterised the side of the Brain in a guinea-pig and as a consequence there was a peculiar spread out position of the tips of the toes, which he attributed to an alteration in the Muscular tense of the corresponding side. Progrès Medical 1875. p. 16.

Another point to which this Physiologist drew attention, and to which reference may be made here, is that all the effects of Section of the Cervical Sympathetic may be produced by mechanical and thermal Excitation of the Brain, and that this Section of the Cervical Sympathetic is followed by Atrophy of the Brain & corresponding Eye, after Several months. From this he draws the conclusion that the results of mechanical and thermal irritation are radically different from those of Electrical irritation; and further he states that the Destruction of Motor Centres is followed by Paralysis of the opposite side of the body or that the Investigations by local Destruction give the results obtained by Electrisation. Archives de Physiologie 1875. vol. ii.

The observations of Eulenberg and Landois must not be passed over. They destroyed a portion of the Cortex by the Actual Cautery, & they found a decided rise of Temperature in the limbs on the opposite side, much greater than that observed by Lépine. Whether this rise in Temperature is to be attributed to the destruction of the Cortex or to the destruction of real Heat Centres, it is not easy to say, but we may note that the investigators were able by Electrical Irritation to obtain a slight and transient diminution of Temperature in the limbs. Hitzig has made observations confirming this rise in Temperature. Centralblatt 1876 p. 260

There have been other workers in this Group of investigations, such as McKendrick, who has shown that destruction of a definite part of the Parietal Lobe in Pigeons causes loss of vision on the opposite side, but space will not allow us to go into further details, and we propose now to close this section of our thesis by a statement of Goltz's experiments with their results. His experiments were conducted with great care, they extended over some period, & being of great importance, they deserve careful attention. Transact.s Roy. Soc. Edin. Jan.y 1873.

Goltz employed quite a new method in his investigations. The old plans of operating were objectionable inasmuch as there was great difficulty in keeping the animals alive long enough for the observations to be of value, because hemorrhage or inflammation of the Brain substance often set in and led to a fatal result before the most important observations could be begun. To obviate these disadvantages Goltz had recourse to a method of removing the Cerebral substance which is often employed for making anatomical preparations of the Blood-vessels. It consists in washing away the Cerebral substance by a jet of water thrown with sufficient force to break up the delicate Brain tissue without injuring the firmer Blood vessels. Goltz applies the jets of water by means of Canulæ variously formed and inserted through openings trephined in the Skull. For a very circumscribed destruction of the Cortex a single opening is sufficient. For a more extended operation several holes were made near Each other, and the Brain substance between them removed by a proce

Pflueger's Archiv xiii 1876 p. 1.

of tunnelling. By a series of operations of this sort Goltz succeeded in one instance in washing away all the Convolutions of one Cerebral lobe, which could be reached by openings through the Skull. The animal lived in this condition for several weeks, & was used for numerous observations. Goltz arranges the results of unilateral Destruction of the Cortex Cerebri under the three headings of Disturbances of (α) Sensation; (β) Vision. (γ) Motion, and the following were the results:-

Sensation. Immediately after Destruction of the Brain substance there is often complete Anaesthesia on the opposite side of the body, and though in a few days this passes off, still some impairment of Sensibility remains, which shows itself by various awkward movements of the limbs on the opposite side.

Vision. At first complete blindness follows an extensive Destruction of the Cortex, the animal striking obstacles on that side. By degrees sight is recovered sufficiently to allow obstacles to be avoided, though there is some permanent defect of vision, in consequence

of which objects seen with that Eye fail to call forth their usual Emotions as in the normal State.

Motion. At first the Paralysis on the opposite side is so complete that the animal falls down, but this passes off, and the animal moves about in an apparently normal way, though a closer Examination will detect some Motor disturbances which are persistent & do not pass off.

When we come to review these different investigations, we will point out the importance of these observations both in Connection with the question of Localisation of Brain Function and also with the Pathological Condition to which we propose Specially to draw attention, and we will give Goltz's reasons for holding that all these Temporary phenomena are due to the Superficial lesions exercising Inhibitory influences over the parts of the Brain lying between the Cerebral Convolutions and the Spinal Cord.

Investigations in Comparative Anatomy &c.

Seeing what different opinions are held on this Subject of Localisation of Brain Functions & what diametrically opposite views are Ex

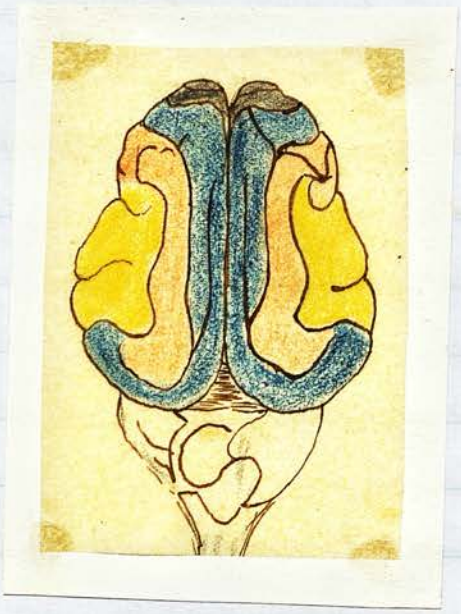
pressed by most competent observers, we are compelled to look around us and see if there are any other sources from which facts can be drawn which may help to elucidate the matter and bring us to the truth. In the domain of Comparative Anatomy little has been done. The only observation we have been able to find is that of Von Gudden who has shown that in the active and nimble squirrel the Frontal or Motor portion of the Cortical Substance is much more developed than in the more tranquil rabbit, a point which would seem to imply that Motor impulses ~~may~~ vary according to the development of the Anatomical organs which are provided for them.

Nussmaul, "Die Störungen der Sprache" Leipzig 1877.

When we come to consider how Anatomy bears on our Subject we have to remember that Anatomy will not of itself disclose Function, it will only help us to explain Function when discovered. In regarding the Brain anatomically we find points that seem to tell in favour of Localisation & others that militate against it. From the form, position, and arrangement of the Convolutions

we do not think that sufficient conclusions can be drawn to furnish grounds for Specialisation of Function. In all animals above Rodents we find the surface of the Brain convoluted, these Convolutions being merely folds of the Brain for the purpose of increasing the extent both of the Pia Mater which feeds the Brain substance beneath, and of the surface upon which may be laid the Grey or Vesicular Nerve substance, now admitted to be the source of power. In each species we have the Convolutions assuming a characteristic form, position, and arrangement. What gives rise to these differences it is not easy to say, but there seems to be something in the idea expressed by Halle, that the Convolutions are produced by the growth of the surface of the Brain being interfered with within the Skull. According to this idea the Brain, if allowed to grow free outside the Skull, would show other forms than it does, when the relation of certain Cranial axes opposes a resistance to the tendency to growth. The Convolutions thus produced must be developed in a direction perpendicular to the axes narrowing the Brain. In other words

See London Medical Record 1875.



if the Prosencephalon were allowed to grow outside the Skull and form a Ball, arrest of developement laterally would form longitudinal or Straight Sulci, while interference with its growth from before backwards would form transverse Sulci or Sulci perpendicular to the others. Thus, in the Fox with its Skull large from before backwards we find a Brain possessing Sulci almost purely longitudinal; whereas in the Cat tribe in which the Skull is more quadrate all the longitudinal Sulci are interrupted by others perpendicular to them. However, whatever it be that determines their form and shape, all we can say is that they seem to be developed according to the amount of intelligence in the animal.

Passing from the Convolutions to the Grey matter we would be inclined to think that the continuous character of this layer, thus connecting together all the Convolutions, wd be against the idea of Localised Centres, for we do not find the Convolutions isolated by any investing membrane, as a group of muscles is surrounded by its sheath of fibrous

tissue. When we look, however, into the internal structure of the Convolutions we do find some points of difference. They are not all constructed alike, and, further, the Arcuate fibres connect together some Convolutions and not others. These two facts of structural difference and grouping of certain Convolutions are in unison with functional differences of the different parts of the Cortex, and if we continue our comparison between the Convolutions and Muscles this connection by Arcuate fibres may point to the combination of certain Convolutions in certain Intellectual acts just as certain groups of Muscles are associated in performing various movements.

Speaking of the internal Structure of the Convolutions brings us to ask what has Histology contributed towards this question of Localisation? In reply to this we may state that of late there have been two very valuable contributions bearing on the structure of the Cerebrum. The first one is by Betz of Kiew who finds that the surface of the Hemispheres is divided by the Fissure of

"Anatomischer Nachweis gewisser Gehirncentren", Centralblatt 1874. P. 578.

Rolando into an Anterior and a Posterior half, differing remarkably in their minute structure. In the Anterior Tract, & chiefly in the fourth layer of the Cortex, he found Giant Pyramidal Nerve Cells with 2 Chief and from 7 to 16 Secondary processes, & the latter still further subdivided into smaller ones. One of the Chief processes is thick at its origin and then divides into further divisions and sends out lateral branches in its course to the Periphery of the Cortex; the other process is slender, & starts from the Nucleus of the Cell, passing directly into the Axis Cylinder which soon becomes thicker and provided with a sheath, and so continues its course as an undoubted Nerve trunk. These Cells do not form a continuous layer, but are aggregated into Groups or Nests of 2 or more Cells, and in younger people these Nests are smaller than in Adults. In the Right Hemisphere the Cells are more numerous & apparently larger than in the Left; and in the Brain of very old people the Nuclei of the Cells are ~~more numerous~~ filled with Yellow-Granules

These cells are found in the same locality in every human Brain, also in idiots, the Chimpanzee, & in several of the lower apes. Betz was next led to examine what had found to be the irritable zone in Dogs, and he discovered in it what proved to be similar Cells arranged in the same way. They are limited in the Dog to the lobe which bounds the Crucial Fissure and to the Anterior half of the posterior Contiguous Convolution. In Man and the higher Apes the greatest numbers of these Giant Pyramidal Cells are situated in what Betz calls the Para-Central lobe. It lies in front of and to the inner side of the Fissure of Rolando, and it is present in every human Brain in a more or less Developed State. It is separated in front by a furrow from the inner surface of the First Frontal Convolution, and, behind, a similar furrow divides it from the Lobus Quadratus and below from the Gyrus fornicatus. Its upper surface passes into the upper end of the central Convolutions. Although topographically these lobes do not seem identical in Man and Animals, yet they probably are, for we find that this

Lobe becomes more and more external the lower the species descends in the scale. Histologically, they are evidently identical. - In the Posterior half of the Brain Betz has found that while there are large Cells in it, yet they want the numerous and long processes of the Anterior half, and layers of Nuclei predominate. In fact Betz has found these Giant Pyramidal Cells in no other part of the Brain but the Anterior half. This discovery of Betz is a very important contribution to our Histological knowledge of the Brain, for, apart from the fact that these Cells correspond with the position of the Chief Centres on the Brain, we have in this distribution of Nervous Elements an analogy with the Anterior and Motor and Posterior Sensitive Sphere in the Grey Centre of the Spinal Cord.

The other Contribution to which we referred is that by Major on the Structure of the Island of Reil in Apes. The Island of Reil has the following characteristics. It is the smallest lobe of the Cerebrum apart from the others; it is peculiar to Man and the higher Apes; it is the portion of the organ which appears

Lancet. July 14 & 21. 1877.

earliest both in the human Brain and in the Animal series; in Man it is very liable to be affected by Pathological lesions; + Lastly Ferrier's Experiments as to its Functions have been quite negative in their results. Major's Microscopic Examinations show that the Pyramidal cells in the Insula of Apes are smaller than in the human Insula, and speaking generally he says that while he finds the Cells in the human Brain not differing very much from those of the Apes in size, he also thinks that the cells of the human Brain have more branches than those of apes, thus forming in Man a richer intercellular Communication than in Apes. He further says that there seems to be sufficient evidence to render it probable that passing from the lower animals upwards towards Man there is a progressive increase in the number of the branches of the Cortical Cells and pari passu an increase in the number of the Cell connexions. This evidence is founded on the simple state of the Cells in the Fœtal Brain, the paucity of the Cell Branches in the Rabbit and other of the lower animals, and the loss of branches

which the cerebral Cells undergo in the ordinary degenerative process. There is great difficulty in proving or disproving the theory which seems to assert a relation between Intellectual power and the multiplicity of Cell connexions, but facts such as those noted above are in favour of it.

We now come to the domain of Pathology, and at once we are met with the difficulty that in this field of observation there is a very great mass of evidence very contradictory in its character. Thus the most recent cases that have been urged in favour of the doctrine of Localisation can be met by an equally large array of cases, such as the American Crowbar case, in which very considerable lesions of the Cortical substance of the Brain have been met with as the result of mechanical injuries or tumours, and yet there have been none of those alterations in Motor Functions which we should expect, according to the theory of "Cortical Centres." Of course we must bear in mind that in former days, when the theory of Localisation was not so prominently before the profession,

lesions were not defined with the accuracy and definition that is now observed. Of late, however, cases have been observed which seem to verify late experiments, & in which lesions found Post Mortem have corresponded with very remarkable accuracy to the regions which the Electrical Observations on the Brains of Monkeys and the implication of certain Groups of Muscles during life had led their observers to expect à priori. Many of Hughlings Jackson's cases might be quoted, but we think one of the most remarkable is given by Hitzig. In this case a small abscess of the Brain formed, as the result of a gun-shot wound of the head received during the Franco-Prussian War, and during the progress of the case Bilateral Convulsions occurred in the Muscles around the Mouth and Nose, and in those of the Tongue, without loss of Consciousness. On Post Mortem Examination the abscess, which was about 2 Centimetres in diameter, was found to occupy that part of the Anterior Parietal Convolution which in the Monkey lies between the Centres for the movements of the

Untersuchungen über das Gehirn, 1874 p. 4.

Mouth and Tongue, which are also Bilaterally excitable from these Centres. This is certainly a case of great interest and value from its occurrence in the human subject, and its careful examination both during life and after death, and supports the idea of Cortical Centres.

Did Space permit we would feel tempted to quote two most interesting cases of Epilepsy reported by Dr Clouston in the Journal of Mental Science, in which the patients lived for some years affected by Epileptic fits, and after their deaths it was found that at certain spots there were Spicules of bone projecting from the internal surface of the Skull and causing corresponding alterations in the subjacent Convolutions. In both cases the lesions chiefly affected the Periphery of the Brain and in their production of convulsions from local irritation are strongly confirmatory of recent theories, & especially of that point to which Hitzig has drawn attention that after Electrical irritation of the so-called Centres in the Grey matter has ceased; the movements which were pro-

-duced under the immediate influence of the Galvanic current have a tendency to re-produce themselves without any further Stimulation but as an after effect of the same, and such Convulsive movements may ultimately develope into Epileptiform Convulsions of the entire body. This fact is of great interest, as it undoubtedly gives an explanation of such cases of Cortical Epilepsy as those noted above, and it also throws light on many interesting cases which have been observed of late, in which there have been Convulsive Seizures as a consequence of some circumscribed irritation of the Cortex. Such Convulsions are at first partial, and become gradually transformed into true Epileptic fits, accompanied by loss of Consciousness. This was so in a case that came under our own observation, in which Convulsive movements commenced in the muscles of the Face & Neck, other groups becoming implicated in definite order, & eventually the fit became general. She died suddenly, and at the Post Mortem, made 8 hours after death, we found a Depres-

-sion of the Skull, the result of an old in-
-jury, and at this point a sharp spiculum
of bone projected from the inner surface
of the Skull, and pressed on the Cerebral
Convolutions, causing a very limited le-
-sion of the inferior margin of the Ascen-
-ding Parietal Convolution. There was some
softening of the Brain substance at the point
of pressure and below it. The Brain was
otherwise healthy, but the Membranes
generally were opaque & thickened. This
case was a good deal elucidated by the
observation of Hitzig to which we have re-
-ferred above, and it also is a confirma-
-tion of Hughlings-Jackson's views on Epilepsy,
which regard it as a discharging lesion of
the Convolutions.

Passing over the not very justifiable case
of Electrical Stimulation of a Cancerous ulce-
-ration of the human Brain reported by
Bartholow, we would, before concluding this
section of our subject, draw attention to the
case reported by Lauder. This was the case Centralblatt f. d. Med. Wiss. 1875 p. 225.
of a Child afflicted with Infantile Para-
-lysis since its third year, the left limbs being

chiefly atrophied, and at its death when 15 years of age the Post Mortem showed, in addition to the Spinal lesions, the 2 ascending Convolutions of the Brain shorter than natural and not convoluted, while the Parcentral lobe was quite rudimentary.

Remarks on the different Investigations &c.

Having now gone over in detail the various investigations and different observations made with a view of Elucidating the theory of Localisation of Brain Function, we have arrived at the most difficult part of our paper, for we must now examine into this mass of conflicting opinions and draw conclusions therefrom. Taking first the group of Investigations by Local Irritation they seem to show clearly that certain Groups of Muscles can be brought into activity by the irritation of definite points on the Cerebral Lobes. This irritation may affect either the White matter alone, merely passing through the Grey substance, or the Grey matter alone, these areas being thus themselves true Motor Centres, or both Grey and White matter, the influence being conducted downwards by the white matter from

the grey. We shall offer some remarks on these possible explanations of the movements, but may here state that we think the view which attributes them to the action both of the grey and White matter through an influence exer-ted on deeper centres is the more correct one, & further that we look on it as almost impos-sible to prove that the effects observed are due to a vital excitation of the cortex only. No proof of it has as yet been furni-shed, not even by Hitzig or Ferrier.

As regards the first explanation, notwithstan-ding the somewhat conflicting evidence that we have to decide upon, there seems proof that the Convolutions themselves participate in pro-ducing the definite movements that follow the Electri-cal Stimulation, and the experiments of Braun, confirmed by Putnam, are the ones that we rely on for proving this participation. They are founded on the well-known law that the propagation of what we term Neurility, unlike that of Electricity, takes place only at insensible distances. That is to say, if a Nerve be divided, & the two cut surfaces be brought into the closest possible contact

there is still no propagation of the Nerve Excitation from one end to the other, whereas Electricity passes freely across the cut surface. Now it will be remembered that Brown divided with a sharp knife the connections between an "Active Spot" & the subjacent tissues, & it was found that irritation of the "Active Spot" gave no result. Such an experiment wd scarcely prevent the Electric current spreading to the deeper tissues of the Brain, for, as we said above, Electricity will pass across a divided nerve but it would prevent the passage of Neural Excitation or Neurility. We do not attach much value to the objections of M.M. Carville & Duret to these experiments, who try to vitiate them on the ground that the blood effused during the division of the tissues under the "Active Spot" is so much a better conductor of Electricity than the Brain substance that the Electric current no longer penetrates into the deeper tissues unless ~~they are~~ it is made more intense. Burdon-Sanderson found that when he made his horizontal section beneath an "Active Spot" at a sufficiently deep level

that he got the same results as Braun did. The point that has always weighed most with us in favour of the view that the Electric current just passed through the Convolutions and set up its influence elsewhere is the fact that no Mechanical or Chemical Stimulus applied to these definite areas will set up the movements, inasmuch as they cannot pass through the Cortex to reach the White matter and so be conducted, but no doubt if we knew exactly the changes induced by the Electrical Stimulus we would be able to explain why they have no effect. Meanwhile, because such Stimuli have no action on the Areas, we are not on that account to conclude that the Electricity has none. Nor do we think that the conclusion drawn by Hermann and others that we must assume Conduction of the current to deeper centres because the phenomena of Motion are producible after the Cortex has been removed or destroyed, a valid one. This fact only seems to us to show that the tissue under the "Active Spot" is excitable as well as the Surface, it is not an argument against

the Superficial part of the Brain taking part in the phenomena observed. Its presence is not essential to the movements, but when present it is acted on by the current as well as the Subjacent conducting medium.
Granting then that these excitable areas exist in the Convolutions we have next to consider whether they are themselves the Nerve Centres for the movements or whether they are composed of nerve tissue which is placed in connection with deeper Centres, in this case the movements being Reflex in their nature. The most earnest advocates of the first view, or that of Cortical Centres, are Hitzig & Ferrier. In addition to the arguments against Conduction that we have already alluded to, Hitzig holds that the movements produced are due either to an absorption of the Irritation by the Ganglion Cells at the Active Spot & its conversion into Muscular movements, or else it is just at these "Active Spots" that Irritable Nerve fibres approach the surface of the Hemispheres. If this last view be the case, then, he says, the fibres must come to the surface for some object

and most probably it is to fulfil this function of Motor Centres.

Ferrier also strongly supports the idea of Cortical Centres. He explains the fact of movements being produced after removal of an "Active Spot" by the statement that there is only being set up in the Medullary fibres which travel downwards from the Cortex the same process as would be set up by functional activity of the Grey matter of the Hemisphere which corresponds to these fibres. As we have already said, we think this fact of the subjacent tissue being excitable is no argument against Cortical Centres, nor do we think that it is any argument in favour of them. All it shows is that these fibres lie in the paths down which the impulses travel, whatever be their nature or their source of origin.

Another argument adduced by Ferrier is drawn from the effects of Anaesthetics on the Electric irritability of the Cortex & the Corpus Striatum respectively. Complete Anaesthesia prevents the production of all movements on irritation of the Cortex, but Stimulation of the Corpus Striatum gives rise to

movements. This fact has been relied on as indicating that something more than mere Conduction is involved, & as Ferrier remarks "rather favours the idea that the movements are dependent upon the excitation of Centres in the Hemispheres which have lost a function that they formerly possessed." But it seems to us that this fact indicates another important point, that if these Cortical Centres are Motor Centres in the ordinary sense of the word they differ very much from other Motor Centres of the body, as for instance the Spinal Cord & Medulla Oblongata or even the Corpus Striatum above mentioned, none of which are reduced to a state of torpor and inactivity by an anæsthetic, & thus rendered indifferent to any Stimulus. Again, if these areas on the Cortex are really Motor Centres, in the sense that they are points in which Coordination of the movements of the body take place, they are peculiar in not responding to Mechanical or Chemical irritation.

When we recall the Investigations detailed we will see that there is much to lead us to think that the explanation we must assign

to the results of the Excitation of these "Active Spots" must be of a Reflex character. Thus we have seen in Burdon-Sanderson's experiments that "local Stimulation of the White matter immediately surrounding a Corpus Striatum produces localized movements quite similar to those caused by Stimulation of the corresponding Cerebral Surface; from which it may be inferred that when the Surface seems to be stimulated it is really the Corpus Striatum which is affected physiologically by the Stimulus." (Foster). We must not conclude that because certain movements follow on a Stimulation of certain areas that it is a proof that those areas are Motor Centres. If so we ought to say that the Fauces are the Centre for Vomiting because irritation of them causes the act of retching, or that the Centre for Laughter lies in the Sole of the foot because tickling it causes that act. On the whole we are inclined to look on these localised areas on the Cortex of the Brain not as true Motor Centres, for we know that the parts of the Brain containing them, and in some animals, even the whole Hemispheres, may be removed and yet the power of

movement be preserved in the limbs, but rather as "points from which an influence may extend inward towards the Central parts of the Brain, exciting there the immediate Cause of Motor action, and this influence is transmitted through the Cerebral Substance by definite paths as much as is the case of the influence that passes in the ramifications of fibres of the Peripheral nerves." (Dalton). We must also bear in mind that artificial stimulation of fibres proceeding from Centres to different organs produces the same Effect as when they conduct the natural impulses that arise in these Centres. Thus we know that the Inhibitory action of the Vagus on the Heart may be brought into play by stimulating the nerve itself, though we know that in ordinary circumstances the impulse causing it comes from the Cardio-Inhibitory Centre in the Medulla. Alluding to Cardiac Inhibition leads us to observe that in applying the facts ascertained by these experiments of Stimulation to the Elucidation of the Human Brain we must not forget that this method of Electric Stimulation is an artificial one, widely differing from the ordinary Stimuli to which

the Brain is subject during life, and, further, the strength and amount of the current must be considered, for we know the effect of the Emotions on the Heart, how a deep & sudden joy or sorrow will sometimes completely arrest the action of that organ, while similar Emotions of less intensity will cause that extreme rapidity and violence of action which we call Palpitation.
MM. Carville & Duret showed the importance of this point by noting that they could obtain very different results by a progressive increase of the current, but without altering the Electrodes. Centres more & more apart became involved & eventually a General Epileptiform attack was produced.
Schiff looks on these movements induced by Electrical Stimulation as Reflex and his reasons for this view are that they are stopped by Anaesthesia, and that the time taken for the manifestation of the movements is much longer than if the impulse travelled with the rapidity of Nerve force from the area of Stimulation to the Muscles.
While then admitting the Existence of these areas, Stimulation of which will cause certain movements

we do not think that they are Motor Centres, that is Spots to which Stimulations are carried and from which Motor impulses issue, we rather look on them, as we said, as ~~Spots~~ Spots where Stimuli may find their way in and set up action in the Motor organs. And if we look on the Brain with its radiating fibres and layer of Grey matter as a Peripheral end organ, dotted like the Skin & Mucous Membranes with points from which Reflex actions can be set up, Stimulations of different intensities inducing different movements, just as we remarked above had been pointed out by MM. Carville & Duret, then we believe we shall take a view of the organ more in harmony with the facts observed and presenting fewer difficulties than the theory urged by Ferrier and others that its surface is composed of numerous yet distinct Motor & Sensory Centres.

Before going further let us look at a point which bears very much on this matter, and that is the mechanism by which the Cerebrum is brought into connection with the Motor Nerves. One of the first things evident is that there

is not a direct connection between the Brain and Every Muscular fibre, for the Cervical cord contains fewer Nerve fibres than the Spinal Nerve Roots. Again it is well nigh impossible to trace the direct nervous supply of a muscle to the Brain. These facts show us that the Connection between the Central Nervous mass and the Motor organs is a General one, and has not the individuality that recent experiments have been said to show. Each muscle has its own Nerve, but any impulse that may travel along it when it reaches the Cord does not find there a special set of fibres for itself, but it conveys its message to a tract which does duty for other Nerves as well as itself.- Again, the power possessed by the Cord of causing movements Even after Separation from the Brain, must be noted. This is seen in such an experiment as dividing the Spinal Cord of an animal in the Cervical region, when the Creature is still able to put forth movements which in no way differ from those that are Executed when it is in full possession of its Will, but as there is no

connection between the Cord & the Brain the movements cannot be Voluntary. To explain these phenomena there has been attributed to the Cord the possession of Coordinating Centres, which preside over Groups of Muscles. These Centres may be brought into Action either by a Stimulus from above or by a Stimulus brought by some afferent Nerve. In the former case the movement is called Voluntary, in the latter Reflex. Such being the view held concerning the Cord, & seeing the intimate union existing between the Cerebro-Spinal axis, it has been thought that there are grounds for extending this view to the Brain. Accordingly it is now held by some that the Basal Ganglia of the Brain are Coordinating Centres in the same sense, & that either by Direct Stimuli or by Reflex action they preside over Complicated Muscular movements, such as take place in walking. The possession of this Reflex power in the Brain is not a new idea. It was urged more than 30 years ago by our late able and esteemed Professor of Medicine, Laycock, in a paper read at the British Association meeting of 1844. He then argued that the Brain

must be brought under the general law of Reflex-ion so unreservedly admitted in the case of the Spinal Cord, and of the truth of this proposi-tion we have convincing proof in many of the most ordinary actions of everyday life. When the Eyelids wink at a flash of light and an unpleasant odour causes that distortion of the features termed a grimace, we have instances of Reflex action effected through the Brain, all the Nerves involved being Cerebral: so when the whole body Starts at a loud noise we have an Exhibition of Reflex action, where the afferent Auditory Nerve gives rise to an impression which passes to the Medulla Oblon-gata & thence force is emitted which affects most of the Motor Nerves of the body. It does not admit of doubt that among the phenom-ena of Cerebral Activity there is a whole series of manifestations, both normal & pathological, which are of a Reflex nature, & which resemble in every way the Spinal Reflex acts. If we look at the laws which preside over the mechanism of Reflex Spinal actions we see the resemblance between them & Reflex Cerebral acts, first as to the nature

of the tissue in which they are manifested, & Secondly, in the conditions under which they occur. In a Spinal Reflex act the tissue necessary for the manifestation of the movements is the Grey matter of the Cord, and the course of events is this. The peripheral incitation causes changes in certain cells of the Posterior Cornu of the Cord, which changes result in the formation of an amount of Nerve force which then acts on corresponding cells in the Anterior Cornu, and from thence it is distributed to the muscles by the anterior roots of the Spinal Nerves. As regards the conditions under which a Reflex act occurs, we may say that ~~there are~~ it has 3 Periods, (α) that of Incidence, (β) that of Excitation of the Cord into activity, & (γ) that of Emission of the force outwardly. Thus Reflex movements result from a transformation of force, in virtue of which the Sensitive Incitation derived from the Periphery is converted into a Motor manifestation. To put it shortly, Reflex movements are Sensibility transformed.

Turning now to Cerebral Reflex Acts we see in the Cortical Substance of the Brain a tissue

similar to that of the Spinal Seat of Reflex action. The small cells on the surface of the Cerebrum with the deeper large ones exhibit an analogy to the small cells of the Posterior Cornu and to the large ones of the Anterior Cornu, & thus we have an admirable Sensitivo-motor apparatus planned on the same scale as the Medulla Spinalis, & similarly destined to transform a Sensitive Incitation into a Reflected Motor reaction. In this Reflex hypothesis the Sensitive impressions received are transmitted to the Basal Ganglia, there localised, & finally exhibit their Motor manifestations by means of the Cord. Such a view receives support from Burdon-Sanderson's Series of Experiments, and also from the ones by Local destruction of the so-called Motor Areas, in which loss of Sensibility seemed a more marked feature than loss of power as in the case of the dog operated on by Schiff in which a condition of Locomotor Ataxia was produced. In fact the Evidence seems rather to point to these so called Motor Areas being Sensory ones, and we fear Ferrier himself has had some misgivings

on the point if we are to judge from the following passages. Thus at p. 147 he says: "The mere fact that movements result from stimulation of a given part of the hemisphere does not necessarily imply that the same is a Motor Centre in the proper sense of the term. It will afterwards be shown that the movements which result from stimulation of the regions in question are expressive of Sensation, and that the character of the movements furnishes an important index to the nature of the Sensation." Again at p. 268. "The Sensations accompanying muscular action being repeated as often as the muscular action itself, the organic nexus between the Motor & Tactile Centres becomes so welded, that this Sensori-motor cohesion enters like a compound Chemical Radical as a simple factor into every association which Motor Centres can form with other Motor Centres, and with Sensory Centres in general." Such being his view on the connection between Sensation & Motion it seems to us strange that the optic Thalami which he claims to be Sensory should give no Motor Reaction on

Stimulation. It is difficulties like this that have to be overcome in adopting the view of Cortical Centres. The more we consider it the more do we think these results obtained by Electrical Stimulation should come under the Reflex hypothesis. Of course in the case of the Brain, with its many cells all anastomosing with each other, Reflex action becomes more complicated than in the Cord, but the nature of the action is essentially the same, and we notice in the characteristics of these movements obtained by Stimulation many of the points insisted on by Pflüger as marking Reflex action. We cannot go into all the Laws laid down by him on this Subject, but we may take from among them one or two. Thus he says that Peripheric regions are not all equally apt to provoke Reflex movements, and he fixes the places of Election for it on the Skin as the Palm of the hand, Sole of the foot, and the hollow of the Axilla, and for Mucous membranes the Conjunctiva & fauces. Again, he impresses on us that in Reflex actions the nature of the Excitant is important, as is seen in the difference between tickling & firm

pressure. Lastly he points out how Exhaustion suspends Reflex power. We venture to say that in these experiments by Stimulation all these elements exhibit themselves. Thus there are only certain spots on the Brain Surface that respond to stimuli; it is only the weakest current that will excite the movements, were mechanical pressure will not; finally ex-haustion, consequent on the necessary oper-ation, was observed by Hitzig and others to prevent the manifestation of the movements, even on stimuli of a powerful character. It may not also be out of place to observe that the constancy with which these movements follow stimulation of certain areas is also seen in the somewhat constant relation obser-ved between many Incident Sensitive impres-sions and certain Motor Reflections, such as the start of the body following a sudden noise, to which we have alluded and which is undoubtedly Reflex in its nature.

Here we must pause and not enter further into this matter of the Reflex power of the Brain, as we may get drawn into the dis-cussion of the question whether many of

our highest Intellectual operations are not of this Reflex nature, and that would take us beyond the scope of this paper. What we have wished to do is to show the grounds we have for attributing these movements caused by stimulation to a power which the Brain undoubtedly possesses, and we think that such a view meets many points which are otherwise difficult of Explanation, Especially in reference to the results by Local Destruction on which we must now dwell.

We fear this group of Investigations are not in unison with the first series, and do not tend to confirm the idea of Cortical Centres. With no desire to depreciate the value of the investigations by Local irritation we are sure that it is not possible to decide by mere stimulation the question of the Motor or Sensitive qualities of a part. Extirpation is the only method of arriving at a Con-
-clusion on this point, and it was thus we find Magendie Demonstrating the functions of the Spinal Roots. In Extirpation, if these Excitable areas are really Cortical Motor

Centres, when they are removed the move-
-ments could not take place, or rather they
ought to disappear. Such, however, is
not the case. Thus, in the case of the dog
on which Hitzig operated, irregular move-
-ments and not paralysis ensued, and a
similar condition was seen in another dog
on which Schiff operated, extirpating
the Motor Centres. The only result was
Locomotor Ataxia. Schiff went still further.
He destroyed the Motor Centres of the face
in dogs and found that the motions remained,
but tactile Sensibility was lost as a con-
-sequence of which food remained untouched
between the teeth and jaws on the injured
side. This fact seems to show that the so-
called Motor Centres are really Sensory Centres,
and in further proof of this Schiff has
shown a rat in which the Motor Centres of
the Left side of the face had been destroyed,
and as a consequence bread remained un-
-touched on the side where Sensibility was
lost. Out of the somewhat conflicting
mass of evidence furnished by many diffe-
-rent Experiments, one point of great importance

has presented itself in the vast majority of cases, and that is the temporary character of many of the paralytic symptoms that have followed immediately on the performance of these experiments. Various explanations of this fact have been given but its importance is apparent, and it especially concerns Ferrier's experiments for he it is who has obtained symptoms most in accordance with the Irritation experiments, but he kept his animals alive, or they survived for only a few days at the most, and he did not continue his observations to see if any improvement took place. Nothnagel first drew attention to this temporary nature of the Paralysis following these destructive experiments, and it has received confirmation since from other observers as Goltz and Hermann, but the Italian Physiologists Luciani and Lemoigne have made a very clear division in the matter. They show that it is most necessary if we are to get correct results to distinguish carefully between the effects that immediately follow an operation and the effects observed after the organ has had time to recover from the operation.

The first effects they term Disturbances of Function, the later ones Removal of Function. Of the existence of these transient effects there can be no doubt; what then is the explanation? Either the operation per se arrested the function by the disturbance that it caused, or else ~~Some~~ the organ of the function was destroyed and some other organ has taken it up. The former course of events is explained by what is termed the Inhibitory action of the Brain; the latter bears the title of the Law of Substitution or the Vicarious Function of the Brain, and is an old theory. It is, however, the view much in vogue at present, though there is not great unanimity as to how it is carried out, some thinking any part of the Brain will act for any other part, others that it is the symmetrically situated portion of the opposite side. Thus, as one writer puts it, we have the spectacle of a function being driven from one centre to another like a sparrow driven from branch to branch of a tree. The only argument advanced for this Vicarious Function is that after a lapse of some time the same

results will follow from destruction of another portion of the same side. But if the Inhibitory Action of the Brain is the more correct explanation of the transient Paralysis, it will come into play again Equally well when the second removal takes place. Ferrier argues against this Vicarious function of the Brain, and thinks "there is no direct establishment of new Centres, in place of those which have been lost, but that those which remain may indirectly, without assuming any new functions make up for the loss, to some extent at least." This may meet some cases, but not such as one as where the power of Vision has reappeared after destruction of the Visual Centre, for Goltz has shown that this may occur, and we hold that whenever a function persists or reappears after the destruction of an organ it is almost Conclusive Evidence against its being the function of that organ. Much more probable is the explanation that the transient Paralysis is due to the Inhibitory action of the Brain, which is set up by the operation or destruction of tissue,

and is transient in its nature. We have already alluded to the Inhibitory action exhibited by the Vagus Nerve when it is Stimulated and which is also transient, passing off & allowing the heart to resume its Contractile action. It is not Easy to Define this Inhibitory action, but it is an influence that makes itself felt and is a factor that must be taken into account, and we see it in such an Operation as the Division of the Spinal Cord, say of a Dog, in the Dorsal region. For a day or two the Lumbar Centres in the Cord, as the one for Micturition, do not act, being still influenced or Inhibited by the operation, but in a day or two they recover their tone & respond to ordinary Stimuli.

Besides illustrating this Inhibitory action to which we feel inclined to attribute the transient Character of many of the Symptoms, Goltz's experiments so far to make the doctrine of Cortical Centres untenable, for they show clearly that the amount of the Brain Substance removed affects the Symp-toms produced more than the locality oper-ated on. Thus Goltz invariably obtained loss

of voluntary motion with impairment of Sensation on the opposite side of the body no matter what part of the Brain he operated on. These Symptoms were witnessed when portions of the Posterior Lobe, which is held to contain no Motor Centres were removed, & there was blindness whether Ferrier's visual Centre was taken away or not. This fact about the Sight is of interest, as it is confirmatory of the observation made by the old observers that of the intimate connection between the Sense of Sight & the Cerebral Convolutions. In fact Goltz's Experiments seem almost conclusive as to the blindness observed after these Experiments being merely the effect of disturbance; for not only does the Vision gradually return, but it has been shown not to depend on the Compensatory action of the other Centre, because it reappears even in an animal deprived of the other Eye. We mentioned previously that Goltz had been able to wash away nearly the whole of ~~the~~ one Hemisphere, and to keep the animal alive. Now in this case the effects passed off, showing

that it cannot be due to Vicarious action of the same Hemisphere, for there was no Brain substance to assume the functions. On the whole Goltz seems to have made out a strong case in favour of his view that the removal of these localised areas is Inhibitory in its action, that this Inhibitory action spreads to those parts of the Cerebro Spinal axis which lie between the Cord and the convolutions & which no doubt contain Coordinating Centres intimately connected with Motor power, and to whose existence we have already alluded. One other point to which we would draw attention is that very various effects ensue on excitation of one and the same spot, a fact hardly in keeping with separate and special Centres. Thus Bochefontaine found that what were reckoned as the so-called voluntary Centres for movements of the limbs and tail were also the Centres for the Salivary Glands. If we look on the Cortex as a Peripheral surface, the fact of various effects following Stimulation of it as the result of Reflex action is not so strange,

but under the theory that it is made up of numerous and distinct Centres it is not easy to reconcile these facts.
The many other ~~fact~~ points of interest that this subject of Brain Localisation with its numerous experiments raises, such as the reparative power possessed by the Brain-tissue, the validity of the ingenious theory of the duality of the Brain first started by Dr Wigan, and the advisability of Surgical in-terference in a certain class of Brain disorders, we must pass by. Neither have we alluded to the theories of Drs Broadbent & Ferrier with reference to Aphasia, for we have thought it more desirable to examine into the hypothesis on which they are Construct-ed rather than on the facts themselves.
While frankly admitting the value of the experiments that the discovery of Hitzig has called forth and feeling sure that they will be utilised still more in the future, perhaps towards the Elucidation of the ana-tomical Structure of the Brain, we do not think the hypothesis of Local Centres in the Brain has been proved. Until that

is the case all the observations in Anatomy, Pathology, & Clinical Medicine to which we have alluded do not carry the weight they otherwise would. The hypothesis must be proved first, and then these points in Anatomy and these Clinical observations will be of value. Until that time comes they may be explained by the Hypothesis but they will not establish it. Thus the case of Convulsions, associated with a Spiculum of bone on the interior Surface of the Skull, which came under our notice, and which, on the theory of Cortical Centres, seems very confirmatory of Hughlings Jackson's theory of Epileptic discharges, might, we believe, be equally explained by the theory of Reflex action, for just as in Tetanus, we may have the Reflex Sensibility of the Cord so increased by a wound involving the Peripheric termination of a Nerve, that the morbid condition of that disease is set, so the Spiculum of bone in that case may have so raised the Reflex irritability of the Brain that Convulsions resulted, and once established they would recur

just as they do in Strauss. Already our remarks have extended to a greater length than we intended, and we will only add that we agree with Ferrier when, in the introduction to his Book, he says:- "We are still only on the threshold of the enquiry, and it may be questioned whether the time has even yet arrived for an attempt to explain the mechanism of the Brain and its functions. To thoughtful minds the time may seem as far off as ever."

Hydatid Disease in Sheep.

The Pathological facts to which we now purpose to draw attention are furnished by a malady which occurs in one of our chief Sources of Food Supply. This malady is well known & understood, but we have felt that there are connected with it many Physiological & Pathological points of interest that might be made available for the elucidation of questions connected with Brain problems, as for instance this matter of Localisation of Function. It is this that has led us to think over the subject, and while giving a sketch of the

outline of the disease, & we will note the points which we think recommend it as a means of investigation to a greater extent than is the case at present. We shall give some cases to illustrate our remarks, but this paper is by no means a full embodiment of the subject. It is in a great measure only a statement of the ~~grounds~~ thoughts that have occurred to us as grounds for more extended Enquiry, which we trust time & circumstances will yet enable us to take up. And yet we hope these few cases to which reference will be made will show the advantage and usefulness of such an Enquiry, especially at the present time when the efforts of misguided ~~Popular~~ Enthusiasm have narrowed the field of Experimental Enquiry, in this country at least, to only the privileged few. The young practitioner or student has now few opportunities of making any original experimental research in support of his views or opinions, and the Medical graduate, unless he goes abroad and avails himself there of the unrivalled means of research provided, must as a rule obtain his advanced medical Degree by giving a resumé of the labours of others,

supporting or contradicting their conclusions by some of his own; or else he must recount some of his own Clinical Experiences during his early career.

While in the Western Highlands in Medical charge of a patient, whose Mental health required the quiet and retirement of a country retreat, we were one day following our favourite Pursuit of Angling, when we perceived on the bank of the stream a sheep affected with a Rotatory motion, which to our unpractised eye seemed inexplicable. On enquiry we were informed by the Game-Keeper with us "that it was only a Sturdy sheep with a bag in his head." More than this he could not tell, but we determined to look more into the matter, for while aware of these "Circus movements" occurring in Animals that had been operated on, we had no idea at that time that they were to be met with in the course of any disease. In this way our attention was drawn to the Subject, and soon our interest was further aroused by seeing one of these "Sturdies" operated on by plunging a trocar into a soft-curd Spot in the animal's Skull and the withdrawal of a quantity of clear fluid. Re-

lief of the symptoms followed, but we had our misgivings as to the ultimate success of the operation, as the trocar used was neither visibly, nor, in these days of Germs, invisibly clean, and the operation itself had little of the "Suaviter in modo" about it. The result was as we anticipated. In three or four days the animal became generally convulsed and was killed to end its sufferings. We obtained leave to open the head, and found on removing the calvarium the membranes in a State of Inflammation, and on removing them one hemisphere occupied by a Cyst the contents of which were purulent and putrid, very different from the clear fluid we had seen evacuated on the occasion of the puncture. The hemisphere involved was invaded to an extent we had not anticipated, being reduced to a mere thin layer of Nervous matter covering the Cyst. We had seen the animal during life, & beyond the rotatory motion, there seemed no great impairment of motor power, in fact it ran as quickly and naturally as a Sheep in a normal State. Interested in the matter we continued our reading in reference to it, and also saw what cases we could. The fol-

-lowing is a Short Sketch of the Disease, which we feel it is necessary to give, both for understanding the accompanying Specimens and also for recognising the points in which it merits more the attention of Physiologists for the Elucidation of points connected with the Physiology of the Nervous System.

The Disease is not an uncommon one, and has various names, such as Sturdy, Turn-sick, &c. It is the "Drehkrankheit" of the Germans. Its Essential Character consists in the presence in the Brain of an Hydatid, the Cœnurus Cerebralis, which is a Bladder-worm, and the larval Stage of the Tænia Cœnurus, one of the six varieties of Tape-worm infesting the Dog. It was not until 1853, when Virchow-meister made a series of Experiments, proving the matter, that the cause of Sturdy was known. These Experiments consisted in giving Dogs the Hydatides from the Brains of Sturdy Sheep when they became affected with the Tænia Cœnurus. The joints of the Tænia thus obtained were given to Lambs, and by the 15th Day the Symptoms of Sturdy began to appear. Virchow-meister sent joints of the same Tænia to friends in different

N.B.

This fact of the hydatid growing abortive in the rest of the body is important, as if it develops there it wd complicate any investigations, causing perhaps Reflex Symptoms, just as a worm in the intestines may. -

cities, and they all obtained similar results, the Symptoms commencing about the 15th day. In fact there was a good deal of constancy about the appearance of the Symptoms, the vertigo usually appearing between the 15th and the 18th day. In those of the Lambs that were examined after death the Cœnurus was found in all Stages of development in the Cortical substance of the Brain, but in the other organs of the body where it was found, as in the heart, lungs &c, it was abortive. It seemed to flourish only in the Brain. This certainty with which the disease can be induced were it to be adopted as a means of investigation is in itself a favourable point, and one to which we draw attention. Investigations such as this do not come we think within the pale of the Law as it at present stands, and this is a further recommendation to them. More recent experiments seem to show that the period required for the development of the ova in sheep is longer than in lambs, being about 8 weeks. The time requisite for the development of the Tænia Cœnurus in the dog after swallowing the heads of the Cœnurus Cerebralis is about 12 weeks, so

that in about 20 weeks we have the whole of this marvellous Cycle of changes, & wonderful changes they are, almost without a parallel in the history of Cestode reproduction!
Our knowledge of the cause of the disease explains why Sheep kept in enclosures are free from it, for there no dogs are required, but on the mountain side, where dogs are necessary, is where it is most rife. The dogs affected with Tape worm wander about & distribute the ova, which are scattered about by various other agencies; and are swallowed by the sheep while grazing. When the ova arrive in the true digestive Stomach of the sheep, they are acted on by the Gastric juice, which dissolves the coverings and the minute Six-hooked Embryos forthwith make their Escape, as shown by Dr Cobbold. By means of the Hooks they bore their way into the Blood-vessels and are carried to the Brain, which they make their habitat, either from some power of Selection or from the peculiarities of the Cerebral circulation. Arrived in the Brain, they escape from the Blood-vessels and make arrangements for taking up their abode in what is

to be their resting place. By a process of transformation they part with their Hooks and gradually acquire the Bladder-worm state, through the Development of the Caudal Vesicle. To acquire the Polycephalous condition they require some further weeks, but when that is attained we have a cyst such as is seen in No 3. It is a clear transparent-looking bag with a number of whitish granulations on its surface. These are the Heads of the Hydatid, and they possess the peculiar property of being exsertile or protrusible, a characteristic which, as we shall hereafter, is important, as it really makes the Hydatid a Cerebral excitant, inasmuch as these Heads protrude into the Brain tissue to the depth of two lines and are like a number of pin points being thrust into it. The fluid contained in this Cyst is of a clear pellucid character, of a neutral or slightly alkaline reaction, and of a Sp. Gr. of 1008. It differs from Serous Effusions in being almost devoid of albumen, but it has some extractive matters, and, of Salts, chiefly the Chloride of Sodium.

In the Microscopic Specimens Nos 6 will be seen

portions of the Cyst Wall, and in them can be observed the two Coats of which the wall is composed. The outer coat, or Ectocyst, is fibrous in character and Elastic, and is made up of numerous Concentric hyaline layers: the inner Coat, or Endocyst, is a very thin and Delicate membrane Spread over the interior of this previous Elastic hyaline bladder. This Sac is the Mother Sac of the Embryo (Huxley), and corresponds with the germinal membrane of Goodsir. It is Studded with innumerable transparent cells, the Nuclei of which have been rendered distinct by the carmine staining. It is the Seat of Development of the heads, and to this ~~membrane~~ Endocyst they are connected by a Delicate membrane. In Microscopic Specimens N°3 & 4 will be seen one of the Heads. It appears in the form of a tetragon with a circle of Sickle-shaped Hooklets at its summit, and a mouth on each side of the head. The Shortness of the Neck will also be seen and the rings on the Surface of the body. As the Cyst in Specimen N°3 shows, a Single Cyst may support a number of these Heads, and they increase in number with

the age of the Canurus, a point to be borne in mind in investigations.

Another characteristic to which we wd draw attention is that the Cyst is not incorporated with the Brain tissue, but is surrounded by areolar tissue and is readily removed from the Brain in case of operative interference. In fact, in making Post Mortem Examinations on the heads of Sturdy Sheep the Hydatid, if at all on the surface of the Brain, has often fallen out of the cavity of Brain tissue in which it lay if the Brain was at all turned over. This condition of things is of some importance, as in investigations, if removal of the Cyst was determined on at any time that it had sufficiently determined its presence, it wd be satisfactory to know that no adhesions wd interfere ~~wd interfere~~ with the removal, and so the operation would be simplified. That this is the arrangement in the human subject is evident from a case quoted in the British Medical Journal for June 18, 1870, for in describing the Post Mortem the report says:- "On removing the Calvarium nothing unusual was observed, but as soon as

the Dura Mater was detached a considerable portion of a Cyst was seen lying immediately below it in the Right Cerebral Hemisphere. On removing the Brain from the Skull this Cyst readily slipped out from the Hemisphere without discharging its contents". We have sometimes thought that this non-incorporation of these Cysts with the surrounding tissues ought to be taken more into consideration in the question of Treatment, especially in these days when serous Cavities are more freely opened. Such a case as Hydatid of the Liver, pointing externally, & resisting Treatment by puncture, might be removed bodily, seeing that the Cyst is surrounded by but does not adhere to an envelope of condensed areolar tissue.

Lastly, we would note that after a variable time the presence of the Cœnurus in the Brain of the Sheep causes a softening of the Skull at one particular point, the bony roof of the Cranium disappearing by the constant pressure of the Bladder, and in many cases of this disease we will find a soft yielding spot, somewhat variable in its situation, but forming a guide

This complete removal of bony tissue shows that the Brain substance is also really removed & not only thinned out.

for any operative measures. The peculiar character of the Cyst is we think the cause of this absorption, for just as the Protrusible Heads can remove the Brain Substance so also they can Eat away the bone, and we have Sent in a Specimen of this Commencing absorption, in which the bone wears quite a worm-Eaten aSpect. Specimen No 5.

The Symptoms of this malady vary with the Stage of the Disease, but they are such as to be of great interest to the Physiologist. In the early period we find the animal Suffers from Symptoms of Cerebral Congestion Due to the Brain not having become accustomed to the increased Contents of the Skull. Thus, we have red Eyes and dilated pupils. The other Symptom we noticed was that a Sheep So affected Separated itself from the rest of the flock, & Seemed filled with an imaginary nervousness and Dread. While dull and listless about its food, there was no apparent loss of Motor power. Often these Symptoms Subside with the absorption of the Brain Substance, allowing that organ to accomodate itself to the new parasite; but the

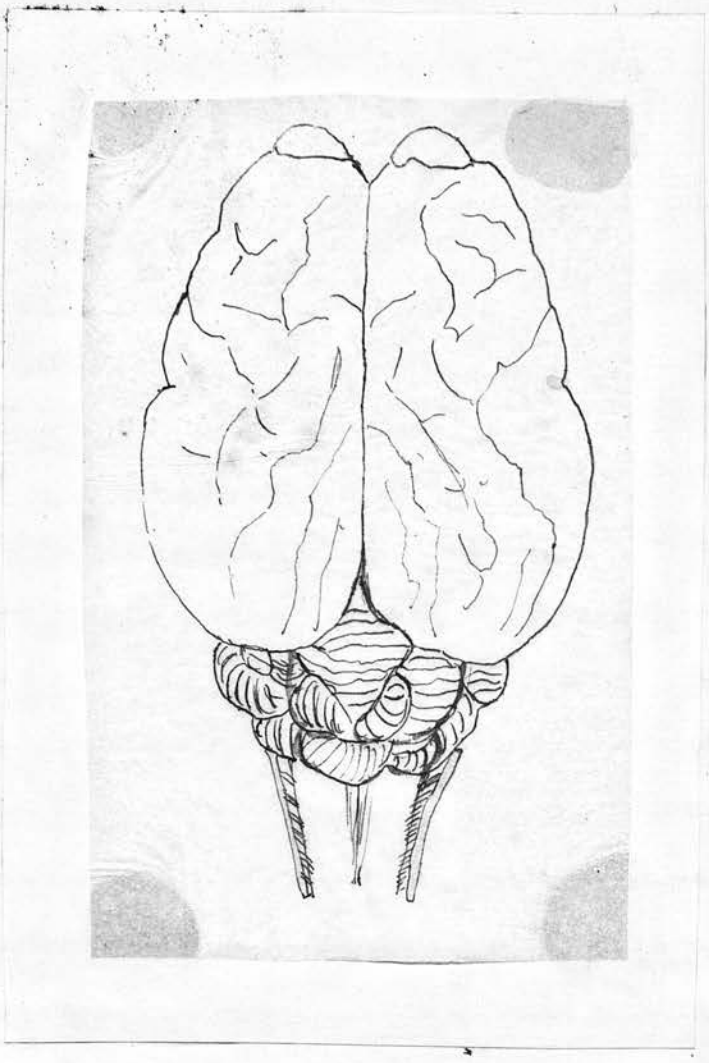
improvement is usually only temporary & the Symptoms increase with the lapse of time. Thus, the head turns to one side, leading to difficulty in grazing; the animal becomes frightened more frequently without any apparent cause; and it takes a pleasure in poring over any running stream, as if the murmuring sound of the water had some soothing influence over it. Eventually there becomes developed that Rotatory movement which is so Characteristic of the disease, but which is not a Constant Symptom. It is altogether a very peculiar movement and we doubt very much whether it is seen in any of the diseases which occur in man. We will here only note the fact of its occurrence, as we propose to consider it more at length when we speak of the cases in which it was observed. We will only say now that its direction is influenced by the seat of the Hydatid. Thus if the Cyst is in one of the Hemispheres the animal turns to that side, if it is situated between the Hemispheres the Head is protruded and Elevated, and the animal

moves in a straight line. If it is in the cerebellum, there is a peculiar uncertainty of gait and a reeling motion. This has led the French to divide Sturdy Sheep into 3 Classes, (α) The Trotter, (β) The Turner, (γ) The Sailor. When once the Rotatory movement is developed it increases in frequency and rapidity, and, interfering with the animal's feeding, eventually leads to its death by exhaustion and emaciation.

Of the Treatment of this affection we do not propose to say more than that it is now founded on the natural cure of Sturdy which is sometimes seen, as when the affected Sheep receives a wound by a fall or otherwise at the point of the skull where it has been thinned or absorbed. Through the aperture thus made the Hydatid, favoured by the fact of its loose attachment to the Brain, escapes. Some rely on merely puncturing the Cyst, but in the majority of cases the usual plan of treatment is the removal of the Cyst itself, and no doubt it is the proper course. For a long time the plan in vogue was to pierce the Brain at its base

by a fine trocar pushed through the cribriform plate of the Ethmoid bone. It was brought into fashion by an incident that happened to the Ettrick Shepherd. As a boy he herded Lambs, when he spent a good deal of his time in knitting, and the bleatings of the Lambs used to attract all the Sturdy sheep in the neighbourhood, who were a great plague to him. One day in not the best of tempers he seized a Sturdy sheep & probed his nostrils up to the very Brain with one of his knitting needles. He was surprised to find that this Evacuated the Hydatid & that the Sheep was cured. He operated on a great many and with some success, but the plan was not so successful with others and fell into disuse. In removing the Cyst it is as well, if the Symptoms allow, to wait for the softening of the Skull, as this does away with the necessity for using the Trephine, which causes a very large opening. Sometimes it is used with success, and we find Sir Astley Cooper, who had a farm at Hemel Hempstead, taking much pride in exhibiting an Ewe which he had

trephined for Sturdy, and from whose cranium he extracted a large Hydatid. She afterwards brought him 5 or 6 good lambs as a return for his efforts. Not so successful was Mr Stephens, who, we read in the Lancet for 1830-1831, related at the London Medical Society, the history of a case in which he trephined for Sturdy. After removal of the cyst he found a large cavity apparently with no signs of Brain tissue, but to assure himself on this point he speaks of letting down a wax-light through the aperture in the ~~Brain~~ Skull, when it appeared that nearly the whole of the Brain was wanting. The hole was closed, and on the following day the sheep was up and feeding, but on the fourth day it became convulsed and died. The Post Mortem showed that only a little of the Brain was left at the base, but there were some remains at the sides forming a sort of Shell. No doubt in this case, as in the one to which we first alluded, Inflammation, supervening on the operation, attacked the Membranes & remaining Brain tissue, causing Convulsions and Death.



Upper surface of Sheep's Brain.

In Microscopic Specimen N° 1 is seen a section of one of the Convolutions of the Cerebrum showing the layers of Cells. - While responsible for the other Microscopic Specimens we owe this one to the Skill of Mr Stirling. -

In Microscopic Specimen N° 2 will be seen a Section of a folium of the Cerebellum

Cerebral Anatomy of the Sheep.

In Specimens Nº 1 & 2 will be seen the healthy Brain of a Sheep. In it we note the Cerebrum forming the large Anterior mass, divided into two hemispheres by a median longitudinal fissure, each hemisphere having on its surface many sulci with Convolutions between them. Behind the Cerebrum, and Scarcely covered by it, is the Cerebellum, divided into a Middle & 2 Lateral Lobes, each having slight & mostly transverse folds. Turning forward the Cerebellum we observe the divergence of the Posterior Pyramids and the Restiform bodies bounding the Fourth Ventricle, in which, at the angle formed by the divergence of the Post. Pyramids is the Calamus Scriptorius, where is the opening into the Central Canal of the Cord. The Restiform bodies form the Inferior Peduncles of the Cerebrum. On turning back the Cerebellum we will see in front of it important structures, the first being a large body divided into four portions by two fissures which cross each other at right angles, thus forming the Corpora Quadrigemina. (They lie above the Aqueduct of Sylvius.) Observe the Anterior pair are larger than the Posterior ones, which

is the case in Ruminants and Solipeds. Externally to the Corpora Quadrigemina, situated on the Optic Thalami, are the Corpora Geniculata, connected with the Nerves of sight. Above the Corpora Quadrigemina are on each side is seen a cleft, termed the Transverse Fissure, and through it the Pia Mater passes to form the Choroid Plexus of the Lateral Ventricle and also the Velum Interpositum, which separates the Optic Thalami from the Hippocampi majores. Proceeding backwards from the Corpora Quadrigemina are the Superior Pedunckes of the Cerebellum, between which spreads the Valve of Vieussens covering in the Fourth Ventricle to some extent. In it arise the Roots of the 4th Nerve. In front of the Corpora Quadrigemina is a small reddish body the Pineal Gland. It is applied against the posterior part of the Optic Thalami and is connected with them and the anterior pillars of the Fornix by two bands of white matter. Lastly, if we gently separate the Hemispheres we note the band of fibres connecting them and termed Corpus Callosum.

On turning to the Base of the Brain, com-

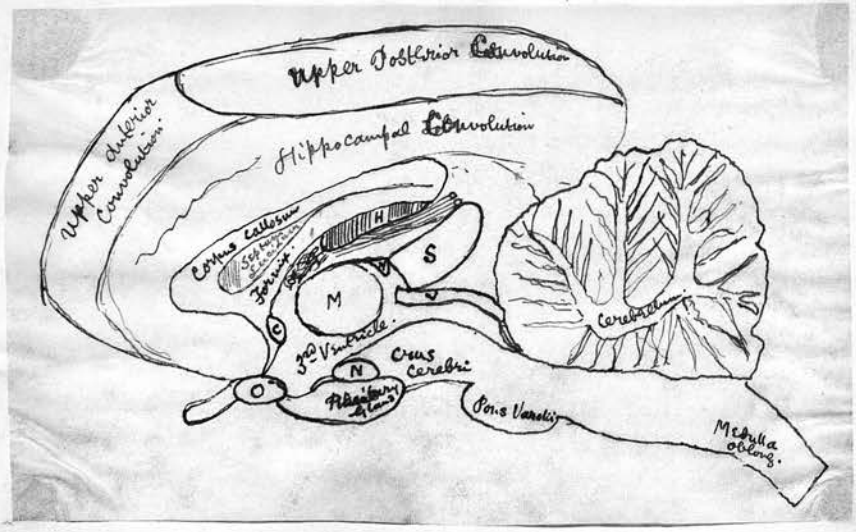
Base of Sheep's Brain.

-mencing from behind, we see the Anterior Py-
-ramids, and if we gently separate them we
will observe the decussation of the fibres.
The Olivary Bodies on each side of them are
not well marked. In front of the Medulla
is the Pons Varolii, its transverse fibres con-
-necting the 2 Lateral Lobes of the Cerebellum,
forming the Middle Peduncles. At the anterior
edge of the Pons appear the Crura Cerebri which
run forward diverging from one another and en-
-closing the Posterior perforated Space, which
forms part of the floor of the 3rd Ventricle, and it is
pierced by small blood-vessels for the Optic
Thalamus. In front of this space lies the
Mammillary body and immediately anterior
to it is the Pituitary body, which has been
torn away in removing the Brain from the
Skull. The two flat Optic Tracts wind
round the front of the Crura Cerebri and meet
in the middle to form the Optic Chiasma,
from which spring the Optic Nerves. In front
of the Optic Tracts are the two white-coloured roots
of the Olfactory Lobule, which enclose the triangular
perforated Spaces representing the extra-Ventricular
portions of the Corpora Striata.

Lateral Ventricles.

Passing to the interior of the Brain, if we slice away the surface of the Cerebrum to the level of the Corpus Callosum, we note the Central White Medullary Substance and the thin Cortical grey layer, & the Corpus Callosum curving in front and behind. By making a slight incision on each side of this last structure we open into the Lateral Ventricles with their two Cornua, the Anterior descending forwards into the Olfactory Bulb, the Posterior passing downwards, outwards & forwards into the substance of the Hemisphere. On the floor of the Ventricles we see in front the pear-shaped Corpus Striatum, the Choroid plexus, and the Hippocampus major, which covers over & conceals the Optic Thalamus, the Velum interpositum lying between them. This Hippocampus Major is really the internal surface of the Convolution which lies on the Corpus Callosum. It unites beneath the Fornix with its fellow of the opposite side, and its External extremity occupies, in the Mastoid Lobule, the cul de sac of the Posterior Cornu of the Ventricle. It receives also the Posterior pillar of the Fornix, which serves as a layer of white matter for it,

and is known as the Corpus Fimbriatum. It is under its free edge that the Choroid plexus passes. If we turn forward the Choroid plexus we will see that they conceal both the Corpus Fimbriatum and also the Optic Thalamus, which can now be brought into view. This last structure and with its fellow of the opposite side are situated in front of the Corpora Quadrigemina & they form the walls of the 3rd Ventricle. They rest on the Crura Cerebri, & indeed they seem to be due to the interposition of a quantity of Grey matter in the Crura. Above they are separated from the Hippocampi by the Velum Interpositum and in front from the Corpora Striata by a slight groove in which lies the Tænia Semicircularis. A portion of the floor of each Ventricle is formed by the Fornix, a triangular white structure. It is prolonged Anteriorly and Posteriorly by four pillars which descend into the substance of the Brain. Each anterior pillar turns down to join the Corpus Albicans & is reflected backward to join the Optic Thalamus. The posterior pillars are connected with the Cor-



C = Ant. Commis-sure.

M = Middle Com-missure

Y = Post. Com-missure.

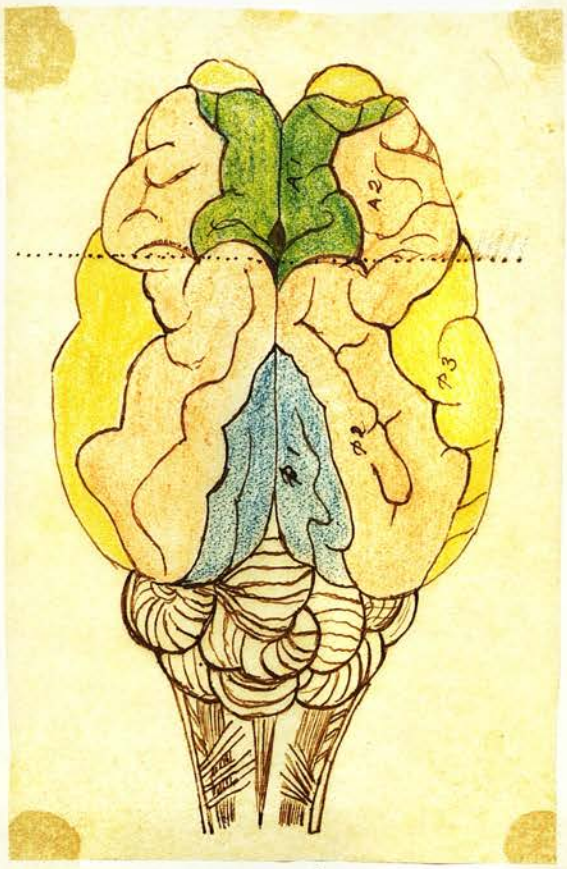
S = Pineal Gland

V = Valve of Vieussens

O = optic Tract.

N = Corpus albicans.

- pus Callosum, and are continued as the Fimbri-
-ated bodies. Between the upper surface of the
Fornix anteriorly and the Corpus Callosum
there stretches a thin membrane, the Septum
Lucidum, which separates the Lateral
Ventricles. Lastly, from the anterior part
of each Lateral Ventricle there leads into the
Third Ventricle a small opening, the foramen
of Munro. This Third Ventricle is the inter-
-val between the Optic Thalami, and it lies
beneath the Fornix. It is crossed in its
interior by the 3 Commissures which unite
the Corpora Striata and Optic Thalami re-
-spectively. In front it communicates with
the Lateral Ventricles, and posteriorly with
the aqueduct of Sylvius. In the accompa-
-nying diagram of a longitudinal section of
a Sheep's Brain will be seen the various
structures and Commissures mentioned, and
also the arborescent appearance of the
Cerebellum produced by the arrangement
of the outer Grey and inner White substance.
We shall close this short sketch of the
Brain by describing and naming the various
convolutions of it as they are seen in the Sheep.



A' = Upper Anterior Convolution.

A2 = Second or Middle Anterior Convolution.

P' = Upper Posterior Convolution

P2 = Second Posterior Convolution

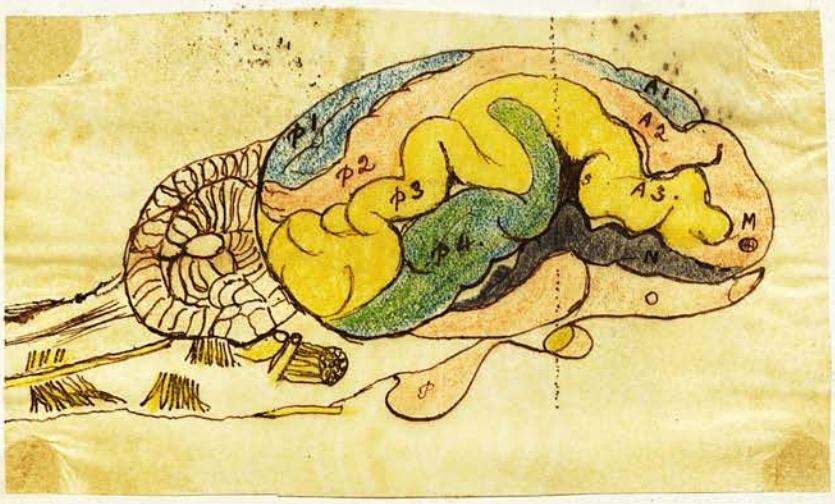
P3 = Third Posterior Convolution.

Convolutions of Sheep's Brain - Upper Surface.

Convolutions of Brain of Sheep.

Looking first at the Superior aspect of the Cerebrum we observe the Median Fissure and the very sinuous character of the Convolutions, which are, however, almost symmetrical on both sides of the Brain. The line drawn in the diagram across the surface of the Cerebrum at the level of the Slyvian Fissure will divide the convolutions into two Groups, an Anterior and a Posterior.

Taking the latter Group first and commencing behind we observe on each side of the middle line a small Convolution, with a Central longitudinal cleft, which forms by its junction with its fellow of the opposite side a V the point being forwards. It is marked P' in the drawing. External to this is another Convolution, also with a Central longitudinal cleft in it. It runs obliquely from behind forwards and at the line which marks the division between the Anterior & Posterior Convolutions it divides into two portions the Inner of which goes to form the First Anterior Convolution, the Outer passes to help in the formation of the Middle Anterior Convolution. This Convolution is marked P^2. We may observe



O = Olfactory Lobe.

N = Supplementary Convolution in Sylvian fissure.

M = Orbital Convolution

S = Sylvian fissure.

P = Pituitary Gland.

Convolutions of Sheep's Brain - Lateral View.

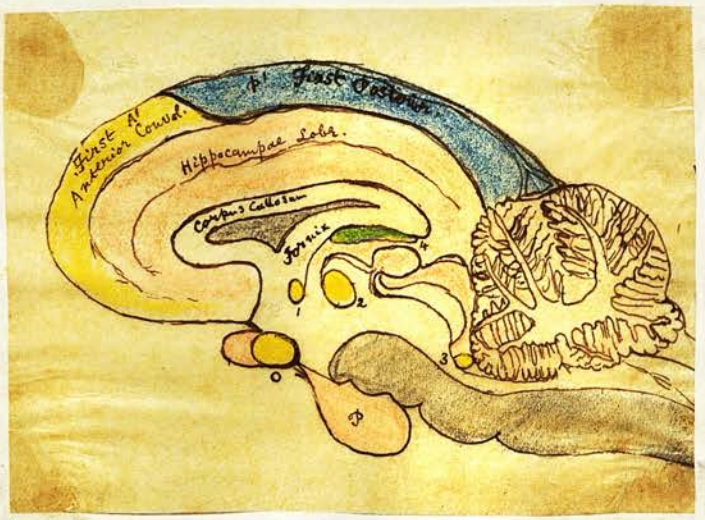
that at the point where this Second Posterior Convolution bifurcates there is a marked Fissure, which evidently corresponds to the Fissure of Rolando in Man.

Next Examining the Brain from a lateral aspect we note the deep cleft forming the Sylvian Fissure and behind it the two Lower Posterior Convolutions, marked P^3 & P^4. They commence behind at the same point & stretch forward in a winding manner as far as the Sylvian Fissure where they unite, only however to bifurcate again, the outer portion going to form the Lower Anterior Convolution and passing towards the Orbital Convolution, the inner portion going to help in the formation of the Middle Anterior Convolution. In this side view of the Brain we observe a Supplementary Convolution lying in the Sylvian Fissure, and also a portion of the Internal Convolution or Hippocampal Lobe.

Another thing that strikes us is the tendency of the Convolutions to group themselves round the Fissure of Sylvius.

When we look at the Convolutions of the Sheep's Brain we are struck with their tortuosity,

O = Optic Tract cut through.



Convolutions - Median Section of Brain.

and their resemblance to those of the Human Brain; and although we have drawn this imaginary line across the Brain for the sake of Simplifying our description, it is easy to see that the Convolutions really traverse the whole Brain from before backwards. As regards the nomenclature we have followed, we have not adopted that of Longet, in which what are the Posterior Convolutions are termed by him External Convolutions, Superior, Middle & So on. Our object in this sketch of this Convolutions has been so to individualise them that they can be identified in our Description of the Pathological Specimens accompanying the Paper, and it will be seen that in our plan there are 4 Posterior Convolutions and 3 Anterior ones, which yet have an intimate Connection.
Lastly, in a median section of the Brain from before backwards, we observe in front the Upper Anterior Convolution, and behind the Upper Posterior Convolution, bounding the Longitudinal fissure, while beneath the latter separated from it by a furrow is the Internal Convolution or Hippocampal Lobe.

Cerebral Circulation in the Sheep.

Seeing that the peculiarities of the Cerebral Circulation, such as the great vascularity of the Brain, the Slowing of the Blood current in the Rete mirabile, and the thinness of the walls of the ultimate blood-vessels, may account for the selection of the Brain by the Hydatid as its habitat, we feel we must give a short account of the Blood supply to this region.

In the Sheep the Carotid Arteries arise from the Right Axillary artery, and when they arrive in the Cephalic region they give off certain Branches, after which they are continued by the External Carotid only. The Internal Carotid, properly so called, does not exist until it makes its appearance as a short trunk within the Skull. The accompanying diagram, and the dissection in Specimen No 4 will serve as illustrations of our description, which need not give all the minute details of the Circulation, but will only embrace the chief points.

The External Carotid terminates in 2 Branches, (1) The Superficial Temporal, and (2) The Internal Maxillary. It is only with the latter we need concern ourselves. Soon after its commencement

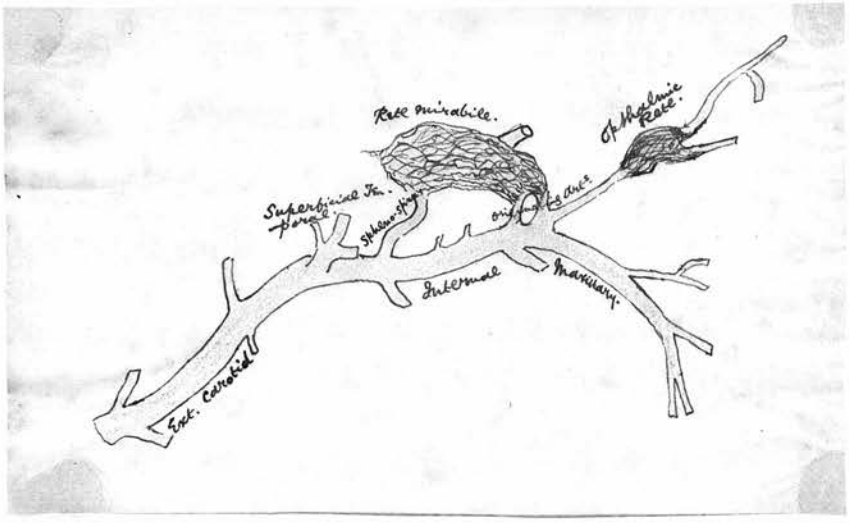


Diagram of Head Circulation in Sheep.

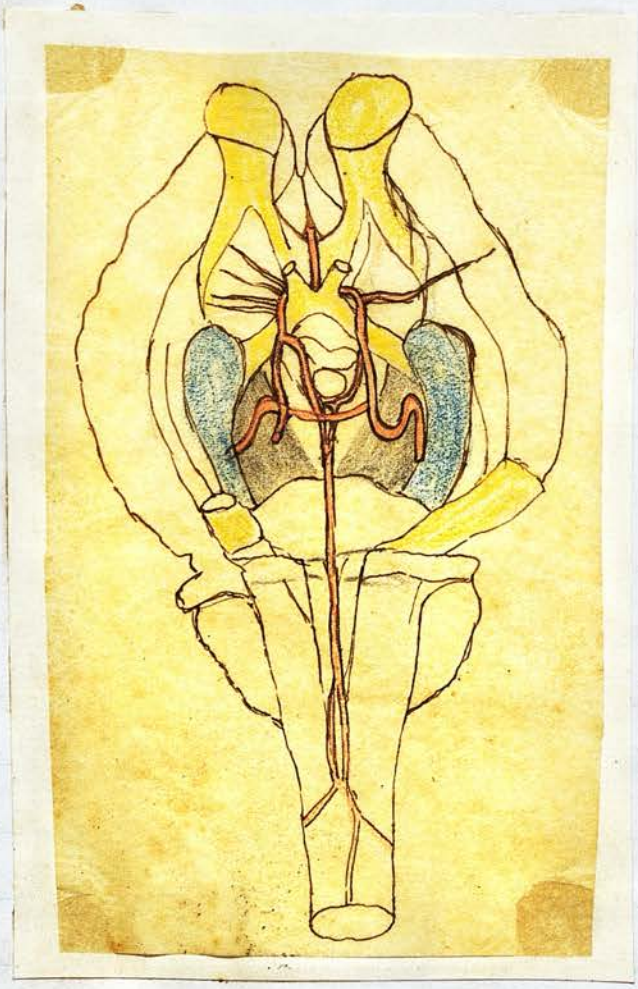
This Artery ~~branches~~ gives off a Branch called the Spheno-Spinous Artery which enters the Cranium by the Oval foramen and goes to aid in the formation of a Remarkable network of arteries called by Galen, who first described it, the Rete Mirabile. But two other arteries also go to form this Structure & they are named the Originating Arteries of the Rete Mirabile. They also spring from the Internal Maxillary Artery, but further along it just at the point where the Opthalmic Artery is given off. They pass backward through the Supra-Sphenoidal Canal, and in Conjunction with the previous vessel, they break up into a mass of Reticular twigs, which form this beautiful provision, the Rete Mirabile. In the Sheep it will be noticed that this Structure differs very materially from the Rete Mirabile observed in the Ox, for instance, where it is an almost circular mass surrounding the Sella turcica, but here we have two lateral Elongated lobes almost independent of Each other, Each forming a Small ovoid mass, Elongated from before to behind, placed beneath the Dura mater & lying on the Side of the Sella turcica. It will also be observed that it arises within the Superior

Maxillary Nerve, part of which had to be dissected off to display the structure. It is composed of a multitude of fine arterial twigs, which anastomose with each other in a very complicated manner. Its Inferior extremity, passing into the Supra-Sphenoidal canal, receives the Generating Arteries, whilst its Posterior extremity, covered by the Clinoid process is in communication with the Spheno-Spinous Artery. The last point to note is that towards its middle part and above, the twigs reconstitute themselves into a single trunk, which represents the Internal Carotid of other animals, & this ~~traversing~~ divides into 3 Branches, the Anterior, Middle & Posterior Cerebral Arteries, which are seen in Specimen.

This Rete Mirabile is found in other animals whose feeding necessitates a Dependent position of the head. No doubt the object of it is to moderate the rapidity of the Blood current as it enters the Cranium, in the different positions of the head, & thus preserve the Brain from any sudden influxion of Blood to the head of the animal on its assuming the Dependent position. Besides furnishing a steady and Equable sup-

-ply of Blood to the Brain, this arrangement is also favourable for a prolonged supply of Blood without the risk of check or hindrance and thus obviating the tendency to congestion of the Brain while the animal is feeding. That this is the intention of such an arrangement is seen in other animals besides those that graze. Thus in the sloth we find the Brachial artery breaking up into a number of small branches running side by side so as to allow of the creature hanging by its arm for a long time, and in some of our domestic animals that stand for a long time, such as the geese, a similar arrangement is observed in the vessels of the legs. In Man we are wont to note and praise the peculiarities in the Cerebral Circulation, how the "Circle of Willis" by its free anastomoses soon overcomes any accidental stoppage at any point of the Cerebral Circulation, how the force of the Blood current is broken by the tortuosity of the larger vessels as they enter the Skull through their bony canals, how they break up into minute arteries in the Pia mater before entering the Brain substance, so as still further to lessen the

Circulation at Base of Brain.



force of the current, how the walls of the sinuses with their unyielding structure are admirably adapted to resist the pressure of the Brain, but in addition to all these points which suffice for man there is added in the case of Ruminants an additional provision to meet the special requirements of their case, a provision which cannot but excite our admiration.

We must also point out that the Opthalmic Artery shows on its course an Arterial plexus very similar to the Rete evidently fulfilling the same objects. This arrangement is not very generally noted.

To return to the Cerebral Circulation, when the Internal Carotid is formed by the junction of the twigs of the Rete, it gives rise to the Anterior, Middle, and Posterior Cerebral Arteries. The Posterior ones pass backward and divide into 2 Branches, one of which runs outwards, and the other joins its fellow of the opposite side and they form the Basilar Artery and its continuation the Median Spinal Artery. The Internal Carotid having passed round the Optic Tract divides into the Middle Cerebral

Artery, which runs in the fissure of Sylvius, giving off numerous Branches, and lastly into the Anterior Cerebral Artery which runs forward, uniting with its fellow of the opposite side, and enters the Longitudinal fissure of the Brain by bending round the Corpus Callosum. This single artery again divides into 2 Branches, which pass from before to behind. Between all these Branches of the Cerebral Arteries there are free anastomoses, and the vascularity of the surface of the Brain is well seen in the Specimen N°

Remarks on the Pathological Specimens.

Specimen N° i. In this case the animal suffered from general muscular tremors with difficulty of locomotion. It was supposed to be a case of the disease termed "Tremblings", but our impression was the Symptoms were due to some Cerebellar disease as there was a decided loss of Co-ordinating power, which was shown by an unsteady gait & by the fact that as soon as the animal was urged to move faster than the ordinary walking pace it fell on its left side & was unable to rise. It was killed

N.B. We regret in this case no note was taken of the condition of the movements of the eyes in reference to Ferrier's observation that Stimulation of Cerebellum causes ocular movements.

on Nov^{r} 17th, and on examining the head we found an hydatid of the Cerebellum, which has destroyed a greater part of the central lobe on the left side together with part of the lateral lobe. The Brain tissue over the Cyst was thin & expanded. Brain otherwise healthy.

This case was of interest to us as confirming the generally received opinion, established by experiment, pathology, & Comparative Anatomy that the Cerebellum is concerned in the Coordination of movements, and most probably it exercises this function from its connection with the Restiform bodies and the Corpora Quadrigemina, the former conducting the impressions belonging to the muscular sense and the latter the guidance furnished by the ocular movements.

Specimen N^{o} 2. In this case the only pathological phenomenon exhibited by the animal during life was that of Rotatory Motion, which w^{d} affect it at short intervals while grazing. The animal w^{d} turn its head towards its own right and execute a circus movement round the axis of its own body. If urged to run, it w^{d} do it about every 20 yards. Otherwise

locomotion was perfect and the animal was active & well nourished. It was killed Aug. 18th, and on Examining the Brain we found the lower part of the Right Hemisphere occupied by a cyst, the Brain over it being very thin and Expanded. On hardening the Brain in spirit we cut through the thin wall of Brain substance & removed the cyst, when we found a cavity as large as a pigeons Egg, and on examination the Basal Ganglia of that side seemed Entirely absent, except the posterior part of the optic Thalamus. The external root of the olfactory Lobe and the Extra-ventricular part of the Corpus Striatum are reduced to a thin transparent piece of nerve tissue. What relation does this lesion bear to the Rotatory movement? As we observed previously this movement of Rotation is a marked symptom of the disease, while in other animals hydatids of different species occur without giving rise to this Symptom, and it has been attributed by some to the heads of the Coenurus being Excertile & able to penetrate the Brain Substance and thus become a Cerebral irritant. One writer,

Brown Séquard's Tabular List.

Turning or Rolling by the Right.

1. Anterior part of optic Thalamus (Schiff).
2. Hind parts of Crus Cerebri (Schiff).
3. Tubercula Quadrigemina (Flourens).
4. Posterior part of middle pedunele of the Cerebellum (Magendie).
5. Place of insertion of Auditory and facial nerves (Brown-Séquard & Martin Magron).
6. Neighbourhood of insertion of the lower roots of Pneumo-gastric nerve. (Brown Séquard).

Davaine, compares the excertile heads to Pin-points, and asks if very manifest phenomena of excitation wd not result in any animal by plunging 200 or 300 Pin-points at a depth of 1 or 2 lines into the Brain substance? If these movements are to be looked on as the result of irritation which interferes with the proper working of the general coordinating mechanism of the Brain, irrespective of the structure involved, it throws light on their following on the destruction or irritation of so many different structures, as seen in the list tabulated by Brown-Séquard. In this case of course the Basal Ganglia were injured, but we shall refer to cases where the movements occurred where these structures were not involved. We think that this disease then, with its strong irritant element in addition to its destructive one, is valuable to the Physiologist as showing that many of the sequelæ of an experimental operation may be set down to the operation itself, which has irritated the Brain and interfered with its harmonious working, and read by its light the forced movements so often observed by experimentors get quite another value. But how does this

Irritative influence act? Not by diminishing the Motor power of the Nervous apparatus, as is Evident from the case we are considering, for the animal was able to put in force Motor power sufficient for running and performing the Rotatory motion, but it acts probably by making the Brain less susceptible to afferent impulses or by rendering it incapable of Exercising the Controlling Power which normally belongs to it. We know that in our normal state by all the avenues of the Senses many & various influences invade our frame, and that they are very necessary for our movements, ~~which~~ and further that unless these influences were held in Control by the Will our movements would be irregular. Remembering this, & also that in animals lower in the Scale than man any interference with the Sources from which these guiding influences come makes itself still more felt, we can understand how a Source of irritation that Exercises an Inhibitory action over the Will or any of the different senses will allow of such movements. In this Disease we sought to find

out evidence of Inhibitory action over any of the Seats by which guiding influences come, and, Struck by the fact that the Rotatory movement was always towards the side of the Brain on which the Cyst was, we have found that some interference with vision has always been present on the opposite side of the body to which the turning took place. Hence while we are inclined to think that the actual movement of Rotation is due to the Irritation of the Cyst which sets in action Nervous force too Strong for the now weakened Control, the direction of the movement is determined by the fact of the Visual power being in abeyance. Of the importance of Sight in our movements the aphorism of Hays, "That we lean on our Eyesight as on Crutches," exemplifies ~~is Evidence~~, and we know that Flourens and Longet induced vertiginous movements in Pigeons, the one by bandaging the Eye, the other by evacuating its humours. This view also derives confirmation from the Statements of those persons who suffer from these disordered movements, as they say that they are usually accompanied by ~~Pain~~ or rather preceded by some disorder of the visual powers.

Hence we do not support the explanation that attributes these Rotatory movements to Spasm of some muscles and paralysis of others of the fact that the gradual disappearance of the Corpus Striatum was not followed by loss of Motor power on the opposite side of the body, all we can say is that it is only in keeping with the uncertainty that exists as to the real function of these bodies, for the view first put forward by Carpenter and Todd that they are concerned in the downward transmission & Elaboration of Volitional impulses has not been proved, and the experiments of Longet, Schiff, & Lafargue, in which the Corpus Striatum was removed, with the Anterior part of the Cerebral Hemispheres, gave mostly negative results.

Specimen No 3. This case is an illustration of the Circus movements occurring where only the Hemisphere is involved, the Basal Ganglia, though altered in position, not being destroyed. The animal showed no loss of Motor power whatever, and ran round rapidly in a straight line, but while at rest and

while feeding its head was turned to the right side and it turned in a circular manner towards its own right, its hind legs forming as it were the pivot on which it moved. There was defective vision in the left eye. Considering the lesion in the Brain, its mental powers seemed very little impaired. It grazed naturally, (although the Rotatory motion interfered with progression, and it was more or less always separated from the other sheep), and when we entered the field it noticed our approach, took safety in flight when we came too near, and exhibited an entire absence of any loss of Motor power.

Specimen No. 4. In this case more than in the last is the hemisphere invaded & yet even here the Animals Motor power was quite good. It will be seen that the region round the Slyvian fissure, which corresponds to Ferrier's Motor region in most animals is reduced to a mere thin layer of tissue, fit no longer to be considered capable of discharging its function, and microscopically showing no trace of structure

but broken down nerve tissue. The cavity holds 3vi of water, and on looking into its interior we observe the Basal Ganglia intact though altered in position, while the Corpus Callosum is pushed upwards & outwards. The Fornix, too, is away from its median position, and the Septum Lucidum is on the Stretch. Cutting through it we see the other Lateral Ventricle with the parts in situ. Posteriorly the Left half of the Transverse Fissure has lost its Concave form and the Left Hatio is flattened somewhat. During life the Symptoms noticed were turning of the Head to the Left Side, while standing and Eating, and well-marked loss of Vision in the Right Eye, but no loss of Motor power. It is such a case as this that makes us doubt what is the real nature of these areas marked out by Ferrier under the guidance of Electrical Stimulation. If the Motor areas he marks out are the only channels by which Motor influences can pass, why is movement still possible after they have ceased to Exist? Of course it will be said that the subordinate Motor Centres in

the Cerebro-Spinal axis have independent powers, and that if the functions of the higher Centres are in abeyance Combined movements may be effected through them. No doubt they are, and is it not probable that it is always so, whether the Brain is intact or not? The difficulty is not got over or simplified by giving these areas the apellation of Psychо-Motor Centres, thus implying that these Cerebral areas have a double function and are concerned in the muscular movements themselves, and in the processes of thought involved in these movements. If such were the case we cannot understand how the animal to which this Brain belonged was able to make the coordinated movements it did when it made efforts to escape us on our endeavouring to catch it. Mere movement does not imply Consciousness, else we must hold that the Brainless frog who lifts his leg to remove the irritating acid applied to it is a Conscious being; but when we see an animal capable of putting into execution a movement involving volition and requiring considerable motor power, then we are

at liberty to hold that its Psycho-Motor Centres are not absent, and if the only region where they are said to exist is destroyed, we are warranted in concluding that that region has had powers assigned to it which it does not possess or which are shared by other parts as well. And that is what we think is the case, and that there is not the Localisation of Function that Ferrier would have us believe. Of a truth if these electrical movements result from the action of Psycho-Motor Centres, they are destitute of one of the chief attributes of Psychical acts, viz Intelligence; and we are sure that, though we can by the Electric Spark decompose water into two different gases, we will never by the same agent accomplish the task of solving the problem of Mind and Matter, any more than the Scalpel of the Anatomist will demonstrate the principle of Life.

Specimens 5 and 6. We have sent in these specimens as showing lesions of the Hippo-campal region, to which region Ferrier has assigned very definite functions. In 5 we see that

the Hippocampal Convolution is reduced to a thin layer of transparent tissue, in some parts being quite destroyed; while in 6 we have the Hippocampal lobe, on the right side, especially implicated. Ferrier asserts that destruction of these regions leads to Paralysis, not of the true Motor kind but due to a loss of tactile Sensation. In the case of the Hippocampal convolution or Gyrus fornicatus the Paralysis is transient, but when the Lobe is involved it remains permanent. Now in neither of these cases was there any loss of Motor power. During the 10 days that No 5 was under observation he was active & brisk on every occasion we saw him, and the only noteworthy symptoms were that he performed Rotatory movements in a wide circle from left to right, and there was impairment of vision in the Right eye, which showed itself by "Shying", like a horse, at any object in his path while running, such as a tree. In 6 the symptoms were turning of the head somewhat to the Right side & impaired vision in the Left eye, but no loss of Motor power, though the animal

was not brisk or lively, and was disinclined for exertion. These cases are of interest as we have here destroyed by this disease a region which Ferrier had to employ a very complicated method to injure. it.

Specimen No. 7. In this case the animal was under observation for some weeks, and suffered from the usual symptoms of Sturdy during that time. Sight was first impaired in the left eye, but eventually the other eye became involved and the creature stood in one spot in the field with its head pushed forward, paying no attention to anything around & refusing to Eat. To our mind it looked like an animal deprived of its Cerebral Hemispheres. If it moved at all it was towards its Right side in a circular manner. It was evident the creature was dying, though in the midst of plenty, and we felt that if it was to be saved the Cyst must be removed from the head, and in a Surgical Capacity and not as a vivisectionist, we determined to Extract the Cyst, by trephining if necessary. Remembering what we had

witnessed as the cause of death in one of the first cases that had come under our notice, where the membranes were inflamed and the contents of the Cyst purulent, we determined to reduce the risk of Inflammation to a minimum by doing the whole operation antiseptically, for of the advantage of this plan in lessening Inflammation after operations our own personal experience of it had convinced us. Having decided on operating we were anxious to avoid the admission of any complication that might vitiate observations or cause death, as we were most anxious to see if removal of the Cyst would restore functions that were in abeyance such as that of Sight. We had also some difficulty in deciding on what side to trephine, as there was no marked paralysis to guide us and the implication of Sight on both sides seemed to indicate that the lesion might be in the middle line of the Brain, implicating structures in each half of the organ. Remembering though that Sight in the left Eye seemed the one first involved and that when Rotatory movements had taken place in the earlier stage of the disease that it

had been towards the Right side, in accordance with the experience obtained from other cases which pointed to the movements taking place always towards the side on which the Cyst occupied, we decided to trephine on the Right side of the Skull. It wd be tedious to detail all the steps of the operation, suffice it to say that in its mode of management every detail of the Antiseptic plan was faithfully carried out. and the whole process conducted under the Spray. Matters also were much simplified by our finding, when the hair was shaved closely off the head, a spot about one inch posterior to the Right Horn where the Skull was softened and pressure on which seemed to give the animal pain, as it immediately began to struggle. The Cyst was evidently pointing here, and this not only relieved us of our anxiety as to where to trephine but also served to dispense with the use of that instrument, which if used wd cause a large opening and increase the Shock of the operation, as we hoped to be able to extract the Cyst through this small aperture by evacuating the fluid first, as in Ovariotomy.

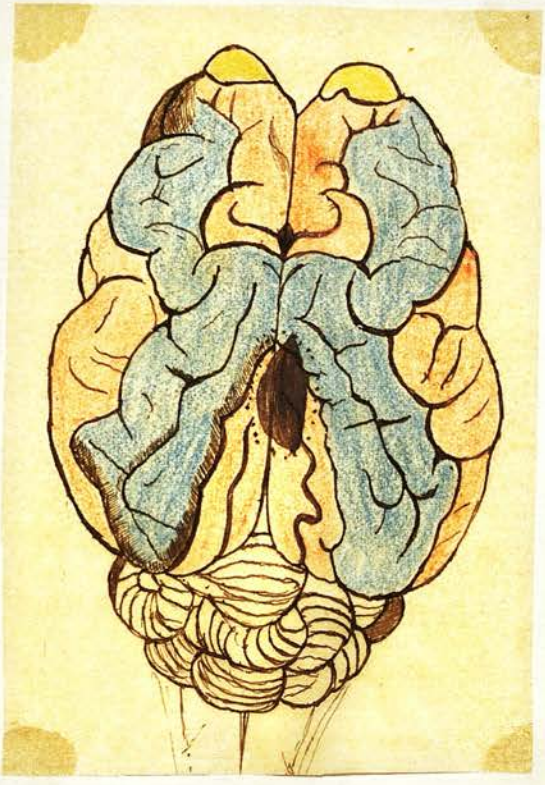
Making a Crucial incision over this ~~soft~~ Spot we reflected the soft parts, cut through the Dura Mater, and Seized the Cyst with forceps. We then with a fine trocar drew off the fluid, evacuating ~~the~~ half an ounce of clear fluid, & then we pulled the Cyst wall through the opening. No investigations were made as to the Size of the cavity, and the wound was closed at once. Here a difficulty met us. During the operation we had put the creature on its back with the upper surface of the Head dependant, so as to allow of the fluid flowing out, but as Soon as the creature resumed its normal position any discharge into the cavity left by the Cyst would gravitate downwards, and drainage would be impossible. How was this difficulty to be met? By no means that we could devise without needlessly complicating the case, and so we decided not to drain it at all, for, though we expected free oozing into the cavity from the Sudden relief of tension, we felt that, if it was not sufficient in quantity to cause tension and consequent Suppuration, being of a non-putrid character, thanks to the

antiseptic precautions, we could trust to the absorptive powers of the surrounding tissues removing a bland and unirritating material. Accordingly we secured on the wound a sufficiently copious antiseptic dressing to last for some days, using the horns as fixed points for securing it, and we then had the creature placed in the stall prepared for it, and, as it was a good deal exhausted by the struggles during the operation, we had it artificially fed with a warm drink of gruel. The operation was done on Saturday Novr 11th 1877. No anæsthetic was administered, first because we were ignorant of how the sheep is affected by chloroform, never having administered it, and having no competent person to give it we were afraid the creature might die under its influence if carelessly given; and, Secondly, we feared it might introduce a complication into the case, which we desired to avoid, as any after symptoms might be attributed to its use; and, lastly, we felt that the operation was, apart from all other considerations, undertaken with the object of saving life, and it was no cruelty to subject the creature to a

minimum amount of suffering, not prolonged one instant more than was necessary or, if it had been a human patient, for the attainment of the summum bonum, Life.

We will not go into all the subsequent history of the case, suffice it to say that next day when we visited the creature, we could scarcely believe our eyes when we saw the change. Instead of the dull, apathetic & blind creature of the previous day we now saw a lively and apparently intelligent one pacing rapidly about the place it was confined in and anxious to escape from its confinement. In fact it was too well: it was in a state of excitement, the result no doubt of the reaction set up by the removal of the cyst, and the pent up nervous force was getting free. However, the improvement continued, though it was interrupted on the 4th, 5th & 6th days by attacks of convulsions, which were general over the whole body and which were so constant as to make us inclined at one time to re-open the wound & see if they were caused by any accumulation of discharge. These by degrees passed off and

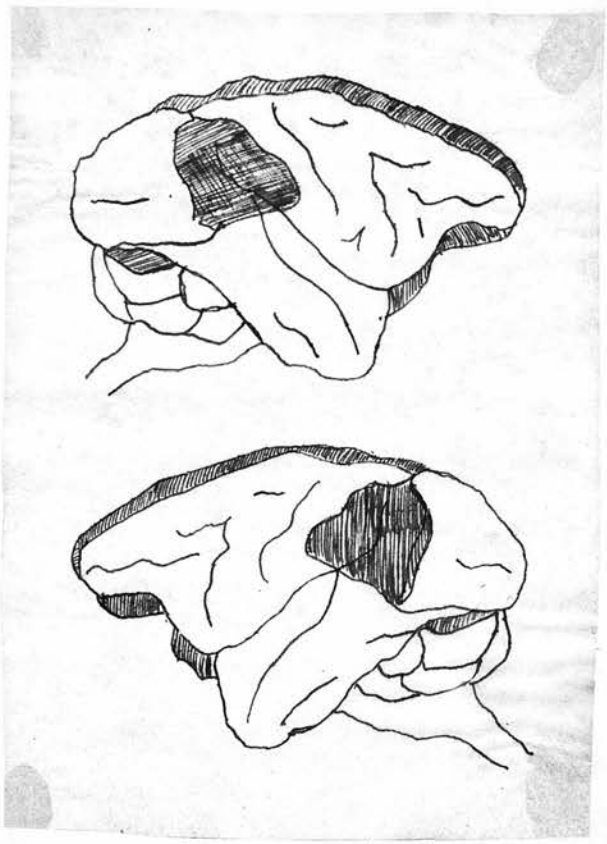
at the end of a fortnight we were able to dismiss our patient permanently into the park with the other sheep. Before sending it out we tried its vision and found that in both eyes it was good, the pupils responding to light and the hand drawn in front of either eye causing it to throw its head back. When in the field it behaved itself just as the other sheep, associating with them and grazing naturally. It seemed perhaps more on the "qui vive" than the others if any one entered the park where they were feeding, but all abnormal movements had ceased and the creature was gaining flesh. We may here say that on removing the dressing on the 15th day following the operation we found the wound quite healed and no further dressing was needed, but we kept the gauze, wrapped round the base of the horns, still on, so as to distinguish him from the others whenever it was decided to kill him. Owing to our leaving the neighbourhood it was necessary to do this 6 weeks after the operation and though we were anxious to have kept him alive longer we were afraid of losing



The spot shaded with ink marks the position of the Cyst as shown by the presence of inflammatory lymph.

sight of him or of anything happening to him, as he was not the source of interest to others he was to us. Accordingly, on Dec.r 22.nd the was killed and we examined the Head. No 7 is the Brain. The Cyst has evidently been situated in the Right Upper Posterior Convo-lution, which as we saw joined the fellow of the opposite side, making a V, and it has also passed over to the opposite Hemisphere, (see drawing) as the presence of the Lymph shows. When we removed the Calvarium there was some adhesion of the membranes to the Skull at this point, and on removing the Brain it was found that the two sides of the Hemispheres were joined by Inflammatory adhesions at this spot quite obliterating the Median Fissure. We broke through these adhesions when we opened into the Central Cavity. It will be seen also that the Convo-lutions at this point are thinned and alter-ed and in at one point there is a mass of Lymph incorporated with the Brain tissue, which cannot be removed without bringing with it the Brain matter. This is seen on both sides at about the same spot, and whether the Hydatid com-menced between the Brain & the membranes and

pressed downwards invading the Brain, or arose in the latter & pressed upwards, we cannot now say, but the point of interest which the specimen shows is that there has been inflammatory adhesion between the upper surface of the Brain and the Dura Mater, and the contraction of the adhesions has so pulled on the Brain that it has yielded and come up to the bony case, with this result that we have in the interior of the Brain a large single cavity formed by the two Lateral Ventricles being thrown into one owing to the Corpus Callosum being dragged up and the Septum Lucidum no longer sufficing to act as a partition membrane between the Ventricles. At first we were inclined to think that the Cyst had occupied the Interior of the Ventricles, but the Structures are so free from disturbance and show so little sign of pressure that we are convinced the other has been the course of events. The portion of the Calvarium accompanying marked No 7, will show the spot where the Cyst was extracted, and we have also thought it of interest to send in the ~~portion of~~ Cyst wall removed from the Brain. Unfortunately portions of it were



The shaded portions in these figures indicate the lesions of the Cortex of the Hemispheres in the monkey, causing blindness. (Roy. Soc.)

After Ferrier

used for microscopic research before we thought of utilising it for the matter of our Thesis, and so it is not present in its entirety as removed from the Brain. Specimen No 6.

Such is a short account of a case that was of much interest to us physiologically, apart from the surgical points involved and the questions in that department that it opens up, and which we must pass by. But it has assured us of the extreme necessity of accepting with great caution the results observed after experimental investigations. The seat of the lesion here, as now seen in the Hemispheres, approximates very closely to the areas Ferrier has marked out as Visual Centres, and had we killed this animal and made an examination of the head we would have been very much inclined to agree with him and have ranged it as evidence on his side, for of the almost complete loss of vision on both sides but chiefly on the right, there was no doubt. But the complete return of that sense on the removal of the irritating cause clearly indicates that it was only in abeyance, and this case shows, what

Goltz's experiments also confirm, to say nothing of the observations of the more ancient but no less accurate observers, that there is a connection between the Cerebral Hemispheres and the organ of Sight, and that many of the results obtained in experiments must be referred to Disturbances of Function rather than Removal of Function.

Conclusion.

With these cases we close our paper, which has extended to a greater length than we intended. As we went along we noted the points to which we desired attention drawn and which we considered that the cases indicated, so we need not recapitulate them here. We are well aware that observations in this disease to be of value must be made with more completeness and thoroughness than we were enabled to adopt in those now alluded to, but many difficulties were in the way, and many of our observations were made on the hill-side, and were chiefly made with the view of seeing if it was worth while to pursue the study of this malady any further with the prospect of throwing light on questions of human Physiology and

N.B. "Nature's Experiments" are as a rule done without any of the Shock, Hemorrhage, Subsequent Inflammation of ordinary operations.

Pathology. Should circumstances allow, we hope to take it up more at length & more thoroughly, for in such a Study as that of the Nervous System Every Source of information should be brought under Contribution, no matter how small the harvest to be reaped. We know that there are many objections to be urged against the results given by Disease, or as they are sometimes termed "Nature's Experiments", but and also against applying what is observed in animals to Man, but as our Struggle is with Disease, the Enemy of Life, it cannot be made too much a Study wherever it shows itself. We spoke at the commencement of our thesis of the advance in our Knowledge of the Nervous System, but we have only to read Ferrier's book, and we feel that we really still are very ignorant on the Subject. It is a book replete with observation, Embodies an amount of Genuine honest work, & Shows moreover the advantage of a Sound Psychological Education, such as we believe the author of it received from Professor Bain, but we close it with the feeling that it has not solved in any way the great problem of how our Will acts. We are also sometimes tempted to ask our

selves whether the general interest aroused by this discovery of Hitzig is not another of the many instances to be found in the History of Physiology of attention being suddenly drawn to some organ, which is forthwith tortured and experimented on by in as many ways as the ingenuity of man can conceive, only to be followed by a period when it is once more allowed some rest or comparative neglect. In fact, if we look at Mind and Matter there is nothing more striking than the reaction which characterises both. We see it in the Pendulum, which obeys the law of gravitation and returns to its Centre, but, as it does so, swings over to the other side; we see it also in the Cord ~~which~~ we twist with some weight attached, which, when it is set loose, rotates quickly and not only untwines itself but takes turn upon turn in the opposite direction. Even so is it with a change of opinion in men. Once set moving they are liable to pass from one extreme to the opposite, and allow themselves to be carried by the recoil beyond the middle line or balance. In the

History of the Nervous System we seem to have reached a similar period. The excitability of the Brain Surface is now in the ascendant, the reaction of the long period when it was regarded as non-excitable: let us watch carefully that we are not carried by the recoil beyond the limits that facts warrant.

Finis.

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5 Castle Terrace, Edinburgh. April 29. 1878.