The Lettsomian Lectures

ON THE CEREBELLUM AND ITS AFFECTIONS.

DELIVERED BEFORE THE MEDICAL SOCIETY OF LONDON,

BY

J. S. RISIEN RUSSELL, M.D., F.R.C.P.,

PROFESSOR OF CLINICAL MEDICINE AND PHYSICIAN TO UNIVERSITY
COLLEGE HOSPITAL; PHYSICIAN TO OUT-PATIENTS AT THE
NATIONAL HOSPITAL, QUEEN SQUARE.

LECTURE I.

MR. PRESIDENT AND GENTLEMEN,—It has been my good fortune to be called on to acknowledge with gratitude many compliments from this society, but no honour that I have hitherto received at your hands can compare to that for which your council has seen fit to select me this evening. I can conceive of no greater privilege than to be chosen as the society's representative to do honour to its great benefactor, Lettsom, in memory of whom these lectures were founded.

In acknowledging my debt to you, I cannot forget that which I owe to my late colleague, Dr. C. E. Beever, who twenty years ago induced me to seek admission to this society as one of its Fellows, and who, three years ago, fulfilled the task which I am about to attempt, in a manner that may well be emulated by succeeding generations of Lettsomian lecturers.

So little was known of the cerebellum in Lettsom's time that it is not surprising that there is no evidence from his published writings that disorders of this organ engaged his attention. It is nevertheless evident, both from his medical publications and from his correspondence, that he took an interest in affections of the nervous system, although he made no more special study of these diseases than is the wont of general physicians.

I make no apology for asking your attention to a few fundamental points in the anatomy of the cerebellum and its connexions, without a clear knowledge of which it would be impossible to appreciate the significance of much that will have to be said of the functions of the organ and of the disorder of these functions by disease.

STRUCTURE.

The student of neurology cannot fail to be struck by the peculiar and distinctive appearance presented by the cerebellum when contrasted with the cerebrum. Distinctive as is its general conformation, made up as it is of a middle lobe and two lateral ones, even more distinctive is the way in which its convolutions are arranged. Like the cerebrum, a grey mantle or cortex encloses white substance, in the midst of which are islands of grey matter, which constitute the nuclei of the cerebellum, but the arrangement of the surface grey matter is altogether different from anything seen in the cerebrum. The external surface has a laminated appearance owing to its being divided up by a series of deep curved fissures, which are arranged transversely and situated close to each other, while separation of the folia into which the surface of the organ is thus divided reveals others hitherto concealed. Section of the cortex presents a dendritic appearance, the *arbor vitae cerebelli*, which is due to the fact that each folia is in turn composed of a series of secondary folia, which in their turn are composed of tertiary ones.

Nuclei.

The most striking of the islets of grey matter revealed by section through the organ is the dentate nucleus (Fig. 1), not only because of its large size, but also because of its distinctive appearance, resembling as it does so closely in its outline and general conformation the nucleus of the inferior olive in the pons. The grey matter of which this nucleus is composed forms a wavy band which encloses white matter, which it shuts off from the surrounding white matter of the cerebellum at all parts except one, where the band of grey matter is interrupted on the mesial side of the nucleus, and allows of free intercommunication between the white matter inside and

that outside the nucleus. The fibres which thus pass from the interior of the nucleus through this part of it, which is known as the hilus, constitute the nerve fibres which form the superior cerebellar peduncle, which connects the cerebellum with the mid and fore brain. There are, however, other islets of grey matter situated in the depth of the cerebellum the importance of which cannot be too strongly insisted on, for although their apparently small size and lack of peculiarity of conformation, as seen on vertical transverse section, may lead to the belief that they are not of much significance, in reality there can be no doubt that they subserve most important functions. There are three nuclei of the kind on each side of the middle line—the nucleus emboliformis, situated on the mesial aspect of and next to the nucleus dentatus; while in the inferior vermis are situated the nucleus globosus, still more mesially placed, and the tegmental or roof nucleus, also known as the nucleus fastigii, close to the middle line, but more ventrally situated, and occupying the anterior part of the vermis.

Fig. 1.—Nuclei of cerebellum (Stillings). o, Inferior olive. d, Dentate nucleus. e, Nucleus emboliformis. g, Nucleus globosus. t, Tegmental nucleus.

Peduncles.

The superior cerebellar peduncle, which has its origin in the dentate nucleus, is the only purely efferent tract from the cerebellum, and passes forward to the mid-brain to reach the red nucleus, to which and to the oculo-motor nuclei collaterals are given off, while others of its fibres pass on to terminate in the optic thalamus, and, according to van Gehuchten, some cross the middle line to end in the thalamus of the opposite side. It is important that we should remember in this connexion that nerve fibres pass from the thalamus to the cerebral cortex, and that a communication is thus established between the cortex of one cerebral hemisphere and the opposite half of the cerebellum and its nuclei. Another fact that must not be lost sight of is that from the red nucleus, to which so many of the fibres of the superior cerebellar peduncle pass, there emanate fibres which constitute the bundle of Monakow or rubro-spinal tract, which crosses the middle line and passes down the lateral column of the medulla oblongata and spinal cord (Fig. 2). There is thus established an indirect communication between one half of the cerebellum and the same side of the spinal cord—an interesting fact that will have to be further emphasized later when we come to consider other connexions between the cerebellum and cord, for this homolateral tendency becomes strikingly evident in contrast to the well-known crossed connexion which exists between the cerebrum and spinal cord.

The middle peduncle of the cerebellum has its origin in the nuclei pontis, and, forming the transverse fibres of the pons, passes across the middle line to the opposite cerebellar hemisphere. There is thus established another indirect connexion between the cerebrum and cerebellum through the cerebro-pontine fibres, which, having their origin in the brain, terminate in the pons by arborizations around the cells of the nuclei pontis. It has hitherto been supposed that this tract takes its origin in the excitomotor cortex of the Rolandic region and the adjoining frontal lobe; but Sir Victor Horsley and Dr. R. H. Clarke are of opinion that this point requires further consideration, and adduce the following reasons for regarding the

Fig. 2.—OT, Optic thalamus. RN, Red nucleus. DN, Dentate nucleus. C, Cerebellum. F, Afferent cerebellar tract (Flechsig). M, Rubro-spinal tract (Monakow's bundle).

temporal rather than the frontal lobe of the brain as the most important part which is associated with the cerebellum through the pontine nuclei. They point to the fact that it is now generally accepted that Déjerine is correct in his opinion that a temporo-pontine bundle exists which takes origin in the middle third of the temporal lobe, occupies the outer fifth of the cerebral peduncle, and terminates in the pons, and as the temporal pallium is the seat of projection of the auditory paths, they consider that it is not unreasonable to regard it, rather than the excito-motor gyri, as being also the area in which the vestibular sensations are represented. They further point to the fact that their view receives support from Charles K. Mill's conception of the subject, for he figures "equilibratory" and "orientation" in the posterior third of the second and third gyri of the temporal lobe.

The inferior peduncle—otherwise commonly known as the restiform body—is peculiarly interesting in virtue of its complexity of composition, and because of the important connexions which it establishes between the cerebellum and other parts, notably the labyrinth. Like the middle peduncle, it is composed—in the main, at any rate—of afferent fibres, which, having their origin elsewhere, terminate in the cerebellum. Some of these (bundle of Flechsig) are derived from the cells of Clarke's column in the spinal cord, and end in the grey matter of the cortex of the forepart of the vermis. Others are derived from the olivary nucleus of the medulla oblongata, cross the middle line, and enter the inferior peduncle of the opposite side, to terminate in all parts of the cerebellar cortex. Yet others are derived from the cells of the reticular formation of both sides of the pons and the lateral nucleus of the medulla, while there remain those which come from the vestibular nerve, and from the nuclei in which this nerve ends. These pass to the tegmental or roof nuclei of the cerebellum.

Paracerebellar Nuclei.

In the grey matter on the inner side of the inferior peduncle certain groups of nerve cells

Fig. 3.—Transverse section of pons (modified from Schäfer). P, Pyramid. R, Restiform body. D, Deiters's nucleus. V, Nucleus of vestibular division. C, Ventral nucleus of cochlear nerve. VII, Facial nerve. VIII, Auditory nerve.

nucleus fibres pass down the ventro-lateral region of the spinal cord on the homolateral side, forming a well-defined tract, which can be traced to the lowest region of the cord; while others pass forwards in the posterior longitudinal bundles to reach the oculo-motor nuclei. From Bechterew's nucleus and the neighbouring grey matter fibres pass in the posterior longitudinal bundles of the same and the opposite sides, and accordingly bring this nucleus into communication with the oculo-motor nuclei; while others pass dorsalwards to the spinal cord, and thus connect the nucleus with the ventral horns.

CONNEXIONS.

Horsley and Clarke, as a result of localized destructive lesions of the cerebellum, found that no fibres derived from the cortex of the cerebellum pass into any of the peduncles, and that all of the fibres which leave the organ through its peduncles have their origin in one or other of the nuclei. They found, moreover, that the cortex is related to the homolateral nuclei, and they have not been able to trace any cortico-nuclear fibres which cross the middle line. The roof nucleus is regarded by them as probably the most important of the nuclei for associating the corticofugal impulses, for they find that it is connected

with practically all parts of the cerebellar cortex. This nucleus has long been known to be intimately related to the vestibular nuclei, for the observations of Kölliker, Edinger, and Ramon y Cajal have made this evident; and Horsley and Clarke, after very limited lesions of the nucleus, have been able to trace degenerate fibres from it over the superior cerebellar peduncle to the vestibular nuclei and *locus coeruleus*. These observers find that the nucleus globosus is not in any way related to the lateral lobe or flocculus, but that it essentially appertains to the vermis system. The dentate nucleus, on the other hand, they find has very little to do with the vermis, and no connexions with the flocculus and paraflocculus, but is intimately associated with the pennate lobules.

Cerebro-spinal System.

Before calling your attention to certain other connexions of the cerebellum it is necessary for me to remind you briefly of the afferent and efferent connexions between the spinal cord and cerebrum (Fig. 4). Some of the fibres derived from posterior spinal nerve roots cross in the posterior commissure, and then pass up in the dorsal tracts and grey matter to terminate in the nuclei of Goll and Burdach in the medulla. From these nuclei fibres are derived which cross the middle line and proceed brainwards as the fillet, which terminates in the optic thalamus, from which fibres emanate which pass to the sensori-motor cortex of the Rolandic region of the brain. The neurons of the sensori-motor area give origin to fibres which pass through the internal capsule, crus, and pons, and, having reached the lower end of the medulla, the bulk of them cross the middle line and pass down the opposite (contralateral) pyramidal tract, to terminate at different levels, and convey impulses which reach the muscles through the neurons of the ventral horns, whose axons constitute the peripheral motor nerves. Thus, afferent impressions which enter the spinal cord can pass to the cerebral cortex, and efferent impulses, evoked in the cortex, can reach the muscles without reference to the cerebellum in either case.

Fig. 4.—Cerebro-spinal system. OT, Optic thalamus. P, Pyramid. F, Fillet. PCN, Posterior column nuclei.

Cerebello-spinal System.

There are, however, other afferent impulses which can only reach the cerebrum by way of the cerebellum, and an indirect motor path exists from the cerebrum which is equally dependent on its connexions with the cerebellum for the transference of impulses from the cerebrum to the spinal centres, and thence to the muscles. In the dorsal sensory nerve roots are fibres which convey afferent impressions from the muscles, joints, and deeper structures, as opposed to the skin, some of which pass to Clarke's column of cells, from which is derived the dorsal or direct cerebellar tract; while others cross in the anterior commissure, and pass upwards in the ventro-lateral region of the cord, constituting the ventral or crossed cerebellar tract of Gowers. Both of these tracts pass to the cerebellum to terminate in the cortex of the organ, the former, as we have already seen, by way of the inferior peduncle, while the latter courses along the superior peduncle to end in the cortex of the middle lobe. From the cortex fibres pass to the nuclei, and from the dentate nucleus fibres are derived which leave the organ by way of the superior peduncle, to reach the red nucleus and optic thalamus of the opposite side, and through the thalamus connect the cerebellum with the cerebral cortex. From the cortex of the cerebrum, in addition to the direct motor path which has already been described, an indirect one may be traced, which passes to the pons, and thence by way of the middle peduncle of the cerebellum to the cortex of the opposite side of the organ, from which fibres pass to the

roof nuclei, from which others arise which go to the nucleus of Deiters, which in its turn sends fibres down the ventro-lateral region of the spinal cord to the ventral horns. It thus becomes evident that afferent impressions can reach the cerebrum by way of the cerebellum, and that efferent impulses may similarly reach the muscles from the cerebrum by way of the cerebellum. Moreover, this system provides a means by which afferent stimuli can evoke efferent impulses from the cerebellum without reference to the cerebrum (Fig. 5). Another indirect motor path is probably established through the connexion which exists between the inferior olive and the cerebellum, for fibres derived from neurons of the cerebral cortex have been traced to the inferior olive (van Gehuchten).

Fig. 5.—Cerebello-spinal system. T, Tegmental nucleus. D, Deiters's nucleus. F, Flechsig's tract. G, Gowers's tract. R, Red nucleus. OT, Optic thalamus.

which are capable of maintaining station and locomotion without the co-operation of the cerebrum, and there is evidence to show that the afferent impressions concerned are derived from the deeper structures, such as the muscles and joints.

The Labyrinth.

The most important peripheral sense organ from which the cerebellum receives afferent impressions, however, is the labyrinth, and the path by which they are conducted is the vestibular nerve. Taking origin in the ganglion vestibulare, and supplying its peripheral filaments to the semicircular canals, it enters the pons between the ascending root of the fifth nerve and restiform body, and among the important connexions which it forms are included the nucleus of Deiters and that of Bechterew, which we have already seen are intimately connected with the cerebellum. Besides this indirect connexion with the cerebellum Ramon y Cajal considers that some of its fibres pass directly to the roof nucleus of the organ and others to the cortex of the lateral lobe. It also forms connexions with the mesial vestibular nucleus and nuclei of the pons, which permits of another connexion with the cerebellum through the internal arcuate fibres. The connexions of the vestibular nerve with Deiters's and Bechterew's nuclei permit of an indirect communication with the ocular nuclei, but in addition to this a direct path has been traced from the nerve to the sixth nucleus. Afferent impressions from the labyrinth can thus evoke efferent impulses from the cerebellum in the same way as results from the afferent impressions which reach the organ from the muscles and joints.

The Proprioceptive System.

How intimate is the relation of the labyrinth to the cerebellum, and how important is the part which it plays in maintaining the equilibrium of the body has long been recognized, but cannot be better illustrated than by reference to Sherrington's conception of their mode of operation.

As sensation does not accrue as a result of all peripheral stimuli which evoke a central (reflex) reaction, Sherrington adopts "receptor" as the neutral term to apply to the peripheral apparatus which receives the stimulation. He points out that there are two main fields of distribution of the receptor organs—a *surface field*, which is situated at the surface layer of the organism, both external and internal, which he speaks of as exteroceptive and interoceptive respectively; and a *deep field*, which is situated in the tissues of the organism beneath the surface layer, which he designates proprioceptive. The stimulations which occur in the deep field are traceable to actions of

the organism itself, as opposed to stimuli received from without. Hence the term "proprioceptor," which he has applied to the receptors of these stimuli, which are brought about largely, as he says, through the agency of mass, with its mechanical consequences of weight and inertia, and also largely through mechanical strains and alterations of pressure, resulting from contractions and relaxations of muscles. Among the functions subserved by the receptors of the proprioceptive, or deep field, is that of maintaining a state of tonic reaction in the skeletal muscles, which Sherrington regards as concerned with the maintenance of attitude. The receptor organs are found to be more highly developed and of greater importance as the head segments are reached, as contrasted with those at the caudal end of the animal, as is well illustrated by the organs of sight, hearing, and smell in the exteroceptive field, and as illustrated by the labyrinth, which belongs to the proprioceptive field, in that the active agent which excites the receptor in the labyrinth is a portion of the organism itself, and not a stimulus derived directly from the environment, such as obtains in the case of the organs of sight, hearing, and smell. In accordance with what obtains in the case of the proprioceptors of all other segments of the organism, however, although the receptors of the labyrinth are stimulated by the animal itself, this is secondary to the action of the environment on the exteroceptors, which evokes a movement of the animal, which in its turn causes the stimulation of the proprioceptors of the labyrinth. As the segment to which the labyrinth belongs is commonly rigidly connected with the other segments which compose the head, posture and movement of the head cause stimulation of the labyrinth. Sherrington further points out that whereas the proprioceptor of a limb has practically only an influence on the reflex maintenance of posture in that limb, the proprioceptive organ of the head (labyrinth) has not only an influence upon the position of the head itself, including the eyeballs, but in addition exerts its influence on the limbs and trunk. Indeed, all segments of the body are embraced within this field of reflex action. Moreover, whereas the proprioceptors of the limbs give them reflex attitudes which are chiefly concerned with their relation to other segments of the body, the proprioceptors of the head (labyrinth) give an animal a reflex attitude in relation to the external world and gravitation. In common with all reflex systems in which there is a tendency for the nerve centres to fall under the dominating influence of one of their own number, which is so situated as to receive the afferent paths from the group of receptors of the system that are pre-eminently important, the whole reflex mechanism of the proprioceptive system becomes focussed upon the main centre belonging to that group. As the labyrinth is the most important receptor in this system, it follows that the central mechanism of the proprioceptive system is built up chiefly in the hind brain, to which the afferent vestibular nerves pass from the labyrinth. To this region of the hind brain internuncial paths from many proprioceptive centres of other segments converge, which with those of the labyrinth form an organ of confluence of great complexity, which is the cerebellum. This increases in size as it is traced through the animal kingdom, becoming larger as the range and complexity of the movements of the animal become greater. The cerebellum is thus, according to Sherrington, the head ganglion of the proprioceptive system, and it accordingly follows that it is the main ganglion of the system.

It is impossible for me to leave this part of my subject without paying a tribute to my colleague, Mr. Sidney Scott, whose experimental researches on the labyrinth have yielded such brilliant results, but deal with a part of the subject not comprised in this lecture, and which time does not permit me to include in our deliberations.

FUNCTIONS OF THE CEREBELLUM.

To experimental researches we are chiefly indebted for the precise information which we now possess in regard to the important connexions of the cerebellum to which your attention has been called, and it is especially to the discovery of Waller that we owe so much in this respect, for his observation that a nerve degenerates when it is severed from the cells from which it takes its origin has enabled us to determine not only what the connexions of

the cerebellum are, but where the tracts take their origin, and where they terminate, which pass from the cerebellum to other parts of the central nervous system, and which take their origin in other parts and terminate in the cerebellum. It would be impossible to overrate either the importance of Waller's discovery or the use that has been made of it by Marchi, who, by the introduction of a special method of treating nerve tissues so as to reveal the degeneration which results when the axons are severed from the cell bodies of the neurons from which they are derived, has enabled an army of neurological workers to investigate not only the connexions of the cerebellum, but also the internuncial paths which link up various other parts of the nervous system with each other. Aided by the Marchi method, observers have been able to determine that certain tracts which have their origin in the cerebellum degenerate when lesions are produced in the organ, while others fail to do so, which nevertheless in their turn degenerate when lesions are made in certain other parts of the nervous system.

Great as is the debt which we owe to experimental investigations for the light which has now been thrown not only on the precise connexions which exist between the cerebellum and other parts of the nervous system, but also on the direction in which impulses pass along these paths, whether to or from the organ along any given tract, even greater is the amount of our indebtedness to experimental physiology for the knowledge which we now possess in regard to the functions of the cerebellum, knowledge which we are able to utilize in our clinical work with such brilliant results in many cases, not only in so far as we are concerned with diagnosis, but also in regard to treatment. The darkness which obscured the cerebellum in Lettsom's time has been dispelled by the searchlights of experimental physiology, which have illuminated the organ in a way that leaves us in no doubt as to what its chief function is, even if there be any diversity of opinion as to the precise way in which that function is exercised. We can affirm on evidence that is incontrovertible, which began with the discovery of Flourens in 1824, nine years after Lettsom's death, and which has since been confirmed by a host of experimental physiologists, that the cerebellum is concerned with the co-ordination of movement, and that lesions of the organ accordingly result in inco-ordination. In the endeavours that have been made to determine the precise functions of the cerebellum attention has been paid both to the effects of destructive lesions of the organ and to the results of electrical and other forms of excitation.

RESULTS OF ELECTRICAL EXCITATION.

Among those who have directed attention to the latter aspect of the subject it would have been surprising if the name of Dr. Ferrier had not figured prominently, in view of the epoch-making experimental investigations which he conducted on the cerebral cortex with such brilliant results for science and such untold benefit to mankind. The main points that seem proved by his excitation experiments on the cerebellum were that faradic stimulation of certain parts of the middle lobe of the organ resulted in movements of the eyes, and that the head also participated, but that no very satisfactory conclusions could be arrived at with regard to the limbs, in that when any movements were evoked they were too sudden and violent to permit of proper analysis, except that it was observed that they occurred on the same side as that on which the excitation had been applied to the cerebellum. The difficulty of evoking a response from the cerebellum as contrasted with the cerebrum was evident to Ferrier; and so impressed have subsequent observers been in regard to this that it is now admitted by many that the cortex of the organ is non-excitable, and that such movements as can be evoked on faradic excitation are in reality due to diffusion of the current to the nuclei situated in the interior of the organ. The most conclusive proof of the truth of this has been supplied by Sir Victor Horsley and Dr. R. H. Clarke, who, aided by an ingenious instrument devised for the purpose, have been able to localize the stimulus to the individual nuclei of the cerebellum, and to demonstrate that, while the cortex of the organ is non-excitable, an electric stimulus applied to the different nuclei readily

evokes a response, which differs according to which of the nuclei is selected for excitation. Thus, on maximal stimulation to the basal region and dentate nucleus there resulted homolateral conjugate deviation of the eyes and head and flexion of the homolateral elbow, whilst deeper excitation of the paracerebellar nuclear region caused in addition extension of the contralateral elbow, hyperextension of the neck and trunk, and forcible extension of the lower limbs. We are thus very strongly reminded of the clinical picture which Dr. Hughlings Jackson described so long ago as 1871, as produced by a cerebellar fit, in which the head is retracted, the trunk arched backwards, the upper limbs flexed and the lower ones rigidly extended.

We are fully prepared for the results which Horsley and Clarke have obtained in so far as the eye movements are concerned, for it will be remembered that the superior cerebellar peduncle takes its origin from the dentate nucleus, and that it forms important connexions with the oculo-motor nuclei. The paths by which the discharge travels so as to evoke movements of the limbs may not be so readily perceived, in that there is no direct efferent tract from the cerebellum to the spinal cord. It was at one time supposed by Marchi, Biedl, and others that an efferent homolateral tract degenerated in the ventro-lateral region of the spinal cord as a result of destructive lesions of the cerebellum, and that there was thus evidence that a direct path from the cerebellum to the spinal cord existed. It has, however, been definitely established that the fibres of this tract only degenerate when the nucleus of Deiters has been injured by the lesion of the cerebellum, and that the tract is accordingly a path from Deiters's nucleus to the spinal cord, and not one which has its origin in the cerebellum (Ferrier and Turner, Risien Russell, Fraser and others). It will nevertheless be remembered that Deiters's nucleus is connected with the roof nucleus, and thus an efferent path is established from the cerebellum to the spinal cord. Yet another way in which impulses may reach the cord from the cerebellum is by way of the superior peduncle, through its connexions with the red nucleus, from which, as we have seen, Monakow's bundle passes to the spinal cord as the rubro-spinal tract.

CEREBELLAR INFLUX.

It would be impossible to discuss any problems in neurology which are entirely free from the suggestions of Dr. Hughlings Jackson, whose master-mind has evolved order out of chaos in so many directions, and who was able to predict with so much precision what Ferrier and others have demonstrated in regard to the localization of function in the cortex of the cerebral hemispheres. It accordingly follows that Dr. Jackson long ago formed a very definite conception of the cerebellum in its relation in function to other parts of the nervous system. He considers that all parts of the body are represented both in the cerebrum and cerebellum, and that these two organs are constantly in co-operation, both of them taking part in every operation. There is, according to Dr. Jackson, an interaction constantly going on between the cerebrum, cerebellum, and spinal cord; and if one of these is put out of action from any cause the energy from the remaining parts must assert itself. He speaks of the energy which is derived from the cerebrum and cerebellum as cerebral and cerebellar influx; and he regards these higher centres as constantly exercising an influence on the lower ones in such a way that, if the cerebrum be removed, the cerebellum is no longer hampered, and can exercise its full effects on the lower centres. This flow of nerve energy from the cerebellum he speaks of as the cerebellar influx.

Among the results of my experimental investigations on the cerebellum, there were some that appeared in opposition to Dr. Jackson's view of the action of the cerebellum, and which seemed in accord with a view advanced by Sir William Gowers to the effect that one-half of the cerebellum exercises an inhibiting or controlling action on the cortex of the opposite cerebral hemisphere. The evidence that seemed to point to this was that the excitability of the cortex of the Rolandic region of the opposite cerebral hemisphere was increased to faradic stimulation after ablation of one half of the cerebellum, and fits induced by the intravenous injection of absinthe resulted in marked

exaggeration of the discharge from the opposite cerebral hemisphere, so that tracings obtained from the muscles of the limbs revealed an exaggerated clonic fit on the homolateral side, while from the limbs of the contralateral side an almost tonic discharge was revealed.

Although it was not possible for me to reconcile the results of my experiments with Dr. Jackson's views at the time when my work was published, it never occurred to me otherwise than that future research would either reconcile what then appeared to be discrepancies between my results and his views, or prove that some fallacy had entered into my experiments of which I was not then aware. Thus it is that, in the light of more recent experimental investigations, I am now convinced that my results are capable of a different interpretation to that which seemed most obvious at the time when they were published, and that there is nothing in them that can be regarded as in opposition to Dr. Jackson's view, which has since received the confirmation which was to be expected from the results of the investigations of numerous experimental workers.

Bouché has determined that fits induced by intravenous injection of absinthe in an animal deprived of one cerebral hemisphere were clonic and mainly flexor in type from the intact cerebral hemisphere, whereas the fit on the other side was tonic and chiefly extensor. Section of the mesencephalon during the fits abolished the clonic discharges and only allowed the tonic to continue. Even more striking are the results of Leonard Hill, who was able to alter the character of the fit from tonic to clonic at will, according as he interrupted the arterial supply to the cerebrium by clamping the vessels or allowed the blood charged with absinthe to reach the brain.

DECEREBRATE RIGIDITY.

Sherrington has shown that removal of the cerebrum results in what he speaks of as decerebrate rigidity, which fully accords with Dr. Jackson's view of cerebellar influx. Moreover, he found that this rigidity could be abolished, and was replaced by flaccidity in the homolateral limbs on hemisection of the spinal cord in the cervical region, which makes it evident that the tonus is derived from the mesencephalon or cerebellum. Sir Victor Horsley, acting on Dr. Jackson's suggestion, divided the mesencephalon at the level of the intercollicular groove, and thus allowed of decerebrate rigidity appearing. Removal of successive sections of the cerebellar cortex produced no appreciable effect on the hypertonus until the sections involved the intrinsic and paracerebellar nuclei. A large horizontal lesion, separating the dorsal half of the cerebellar cortex without involving the nuclei, was also made three weeks before the division of the mesencephalon, again without any appreciable effect on the decerebrate rigidity which resulted in these animals, as compared with that which obtained when a similar section of the mid-brain was performed in normal animals. Thiele, in his researches undertaken with a view to determine the source from which the hypertonus which constitutes Sherrington's decerebrate rigidity is derived, found that the chief source of this energy was at the level of the paracerebellar nuclei. Successive lesions of the mesencephalon, commencing in front and proceeding caudalwards, failed to affect the decerebrate rigidity until these nuclei were reached. The experimental evidence is thus very convincing, both as proving that the nuclear region of the cerebellar complex is the source of the energy which constitutes the cerebellar influx, and as thus confirming the view enunciated by Dr. Jackson more than thirty years ago.

A crossed relationship between one half of the cerebellum and the opposite cerebral hemisphere, however exists, as we have already seen, and this is further emphasized by the fact that in cases of defective development one cerebral hemisphere and the opposite lateral lobe of the cerebellum have both been found atrophied, while the inferior olive homolateral to the affected cerebral hemisphere has shared in the defect.

MOTOR CENTRES IN CORTEX OF CEREBELLUM.

There are those like Adamkiewicz and Prüss, who would have us believe that the cerebellum is exclusively a central organ for bodily movement, and as such possesses localized centres for movement in its cortex. According to these

observers centres exist in the cerebellar cortex which are related to the homolateral limbs, excitation of which evoke contraction of the muscles. Each anterior and each posterior extremity is supposed to have its own special centres, the two anterior and posterior extremities having each a special centre, whilst all the four limbs together have one in common.

My own experience makes it impossible for me to accept such observations without considerable question, for all that I have seen justifies the belief that Horsley and Clarke are correct in considering that the cortex of the cerebellum is inexcitable, and that such movements as result from electrical excitation are the outcome of spread of the stimuli to the cerebellar nuclei.

All the facts that have been best established in regard to the cerebellum are in accord with the view that its cortex is concerned with the reception of afferent impressions which are derived from deeper structures like the muscles and joints, as well as those which the organ receives from the labyrinth, and that efferent impulses are thus evoked from its muscles which are responsible for that degree of tonus in the general musculature of the organism which is essential for the maintenance of attitude, and which makes it possible for co-ordinated movements to be executed.

Thus Probst's conception of the cerebellum is in harmony with the best ascertained facts both as regards the anatomical relations of the organ and as regards its functions. According to his view, which is in harmony with the results of Luciani, Thomas, and myself, the cerebellum represents a regulating apparatus for the muscular system in regard to locomotion generally, the position of the body, and voluntary, automatic, and reflex movements. The muscles are placed in a condition of tension, which tonic state is automatic and independent of the will, and provides that the directions proceeding from the cerebral cortex can be properly carried out.

EFFECTS OF UNILATERAL ABLATION.

Since the time of Flourens experimental investigators have been agreed that destructive lesions of the cerebellum are responsible for disorder of co-ordination, so that such disorders of function are correctly ascribed to affections of the cerebellum when they are met with in our clinical work. From the clinical standpoint, however, it is often even more important to be able to decide whether the organ as a whole is affected, or whether the disease is limited to one part of it, and experimental investigations have done much to assist us to determine which side of the cerebellum is at fault when a morbid process is limited to one half of the organ. The results of experiments have taught us that each half of the cerebellum is most concerned with the homolateral parts of the body, so that after destructive lesions of one half of the organ the inco-ordination and other defects that result are mainly evident on the homolateral as opposed to the contralateral side, as obtains when the cerebrum is similarly under consideration.

After what has been said of the results of stimulation of the cerebellum, we are prepared for ocular defects as a consequence of destructive lesions of the organ. Moreover, as excitation results in turning of the eyes to the homolateral side, we are prepared for what obtains after destructive lesions—namely, turning of the eyes to the contralateral side after "skew deviation" has disappeared. The latter is an immediate and transitory effect of ablation of half of the cerebellum, whereas the other defect continues for some time, although it also ultimately results in recovery. Associated with this abnormal position of the eyes is a coarse form of nystagmus, which occasions jerking of the globes in a lateral direction. The head assumes a fixed position, in which the ear is approximated to the shoulder on the homolateral side, while the chin points in the opposite direction. The trunk is also curved, with the concavity to the homolateral side, and among the evidences of disordered co-ordination which result the animal rolls over on its long axis towards the affected side, a consequence of cerebellar lesions that is more pronounced when the middle peduncle is divided than when one half of the organ itself has been destroyed. The homolateral limbs reveal a greater degree of ataxia than do those of the contralateral side, and since

Luciani first called attention to the fact others have confirmed his observation that the muscles are in a hypotonic condition, while asthenia results in diminished force of contraction. My own results of destructive lesions of the organ are in accord with Nothnagel's view that lesions of the vermis result in much more severe symptoms than do those of the hemispheres, for while my results do not accord with those who have maintained that no disturbance of function results from ablation of the lateral lobe, the increase in the severity of the symptoms which resulted when part of the middle lobe was removed, as opposed to the lateral lobe alone, was out of proportion to the extra amount of cerebellar tissue that was thus put out of action. My results are also in accord with those who, like Marrassini, find that lesions of the median portion of the cerebellum caused disturbances of equilibrium, in which forward or backward oscillations occurred, whereas lesions of the lateral portions result in lateral oscillations to the right or left, as the case may be.

EFFECTS OF LESIONS OF THE LABYRINTH.

What has been said of the important connexions which exist between the labyrinth and cerebellum prepares us for the fact that destructive lesions of the labyrinth result in disorders of equilibrium which are similar to those the outcome of lesions of the cerebellum. Thus it is that lesions of the semicircular canals or section of the vestibular nerve result in disorders of equilibration, in which the animal rotates to the side of the lesion and its homolateral limbs are extended and abducted, as if in the attempt to prevent the rotation, while its contralateral limbs are flexed and adducted. Moreover, the connexions which the vestibular nerve forms with the ocular nuclei prepare us for evidences of disordered innervation of the eye muscles of a similar kind to those which follow lesions of the cerebellum, including abnormal position of the eyes and nystagmus. The similarity between the effects of lesions of the cerebellum and labyrinth is further evidenced by the conclusions of J. R. Ewald and others that the labyrinth exerts a tonic influence on many muscles, while Sherrington points to the fact that the "knock-out" blow, in which the concussion is conveyed by the lower jaw to the labyrinth, reduces "a vigorous athlete to an unstrung bulk of flesh."

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THE annual report for 1909 of the Library Committee of the College of Physicians of Philadelphia states that the number of bound volumes is 81,018, and of unbound reports, transactions, theses, and dissertations is 31,913. There are in addition over 70,000 unbound pamphlets. The cost of transferring the whole collection from the old to the new building amounted to about £165 for boxes, vans, and labour.

THE fifth annual dinner of the Sheffield Edinburgh University Club was held at the Royal Victoria Station Hotel on February 5th, Dr. W. S. Kay, President of the club, in the chair. A company of 108 members and guests assembled to meet Sir Thomas Fraser, the guest of the evening. Dr. Gordon proposed the Alma Mater, and Sir Thomas Fraser replied in characteristic fashion. Amongst the guests were Drs. Sinclair White, Burgess, Dyson, Favell, and Mr. Pye-Smith. A very enjoyable evening was spent

Remarks

ON THE

EFFECT OF BACTERIAL VACCINES ON NUTRITION.

BY LEWIS CAMPBELL BRUCE, M.D.,

MEDICAL SUPERINTENDENT, PERTH DISTRICT ASYLUM.

IF I were asked what is the most common bodily disorder to be noticed in patients suffering from nervous diseases of the type of neurasthenia and the insanities, I would reply, failure of nutrition. There are exceptions to this statement, but it may be taken as a fact that 90 per cent. of the sufferers from functional nervous disorders are thin and poorly nourished. Some of these cases actually die of starvation in the midst of plenty, while others linger on from year to year obstinately resistant to all forms of dietetic treatment. The subject of nutrition, therefore, is an important one for the physician, and any observations which may throw light upon this question are of interest.

In physiological nutrition there appears to be a definite ratio between the nitrogen ingested in the food and the nitrogen excreted in the urine and faeces. When the daily average of nitrogen in the food is reduced, the nitrogen in the excreta also falls, and the body weight is reduced; eventually, however, the body accommodates itself to the altered food supply, a new nitrogen balance is struck, and the weight remains constant.

In acute diseases, notably those associated with fever, the nitrogen balance is upset, the excretion far exceeds the ingestion, and as a consequence there is loss of body weight. When recovery takes place, this condition of affairs is reversed, nitrogen is conserved, more is ingested as the appetite returns, and at the same time the body weight increases, and when recovery is complete a condition of nitrogen balance is again resumed.

In many of the acute insanities, notably maniacal states, the relation of the nitrogen excreted and the urea-nitrogen value of the food ingested conforms to that noticed in acute febrile diseases.

In neurasthenics and cases of chronic insanity, however, there is an entirely different state of affairs. As a rule, the excretion of urea nitrogen is much less than the urea-nitrogen value of the food ingested. If a chart of the nitrogen excreted and the nitrogen ingested in a case of chronic insanity with malnutrition be compared with a

Chart I.—Represents the weekly average of the urea nitrogen excreted, the urea-nitrogen value of the food ingested, and the body weight in a case of acute mania. During the first three weeks, when the patient was acutely maniacal, the excretion exceeded ingestion, and body weight was lost. The latter part of the chart shows the excretion and ingestion during the period of convalescence and recovery, during which period weight was gained.

similar chart of a patient recovering from acute mania (Chart I), they at first sight appear somewhat similar, but a comparison of the body weights at once denotes a

* Delivered at the annual meeting of the Perthshire Branch of the British Medical Association.