A LECTURE ON THE THEORY OF CONSTRUCTION OF THE NERVOUS SYSTEM.

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We come now to the medulla oblongata and pons Varolii, which are important as the seats of nerve-nuclei concerned in circulation, respiration, and other great functions, and, again, as the link between the cerebellum and spinal cord. As a part of the spinal system, the medulla is a prolongation upwards of the cord. Its nerve-nuclei are large, and distinct one from another, as befits the importance and special character of their uses; but they are not otherwise essentially different from the nerve-nuclei in the cord. There is a change in the relative position of the grey and white matter, and a re-arrangement of fibres in the latter. The grey matter, from occupying the axis of the cord, gradually approaches the posterior aspect, and is spread out on this surface, forming the floor of the fourth ventricle; the central canal being laid open at the point of the calamus scriptorius. As the central canal, in successive sections from below upwards, approaches nearer and nearer to the posterior surface, the posterior grey cornua containing the sensory nerve-nuclei are gradually displaced outwards, while the anterior cornua are clubbed together at the median line; so that, in the floor of the fourth ventricle, the motor nuclei are all near the median raphe, the sensory nuclei near the margins. Of the re-arrangement of the fibres it is unnecessary to speak, except perhaps to refer to the decussation of the motor tracts in the anterior pyramids, and this chiefly in order to mention a curious instance of the way in which preconceived opinion can override observation. Under the idea that, because the motor nuclei of the hypoglossal and facial nerves are above the decussation of the pyramids, there is no crossing of the fibres connecting them with the brain, medical men frequently state—and it was till recently so put down in some books—that in hemiplegia the paralysis of the face and tongue is on the side opposite to the paralysis of the limbs, whereas, of course, the contrary is the fact. In the medulla and pons, the communications between the different motor nerve-nuclei and the corpus striatum cross over separately, like the sensory channels everywhere.

The functions of the cerebellum, as I understand them, I can only enunciate and briefly illustrate, without attempting to explain the grounds of my opinion, or meet the objections which might be made.

The cerebellum co-ordinates movements guided by vision, or combines the general movements of the body rendered necessary by special actions ordered by volition. For instance, to illustrate the latter function, I wish to strike a blow. I am conscious only of the desire to hit the object and to hit it hard; this is the only action realised in consciousness. But, in order to carry out the intention, not only must the fist be clenched and the arm shot out, but the feet must be firmly planted, the legs made rigid, the body thrown forward, the chest fixed; and this is what is done for me by the cerebellum.

We can see that there is no such relation between visual impressions and muscular actions as between these and tactile impressions, and any mechanism such as that for reflex response to the latter is impossible as regards vision. Visual impressions are of a different order from tactual impressions (as a cube from a square?), compound or complex; and, as guides to movements, or to be realised in actions, require analysis, so to speak, by the intervention of a ganglion. How the cerebellum is acted upon by the cerebrum or sensori-motor ganglia, and in turn acts upon the cord, we do not yet know. We see its inferior crura, which connect it with the cord, resolving themselves into arcuate fibres, which cross to the opposite side of the medulla, and come into relation with the olivary bodies, and apparently also other grey matter. The middle crura in the pons also cross the median line, and end in nerve-cells here present; these crura probably serving to bring the cerebellum into relation with the nerve-nuclei of the medulla and pons. The superior crura pass to the "red nucleus", a large ganglion resembling the olive in structure, situate in the tegmentum of the crus cerebri; and to the sensori-motor ganglia.

We come now to the crura cerebri; and the first thing to be noted is the enormous accession of fibres in the pons between the passage of

the medulla under the bridge below and the emergence of the crura above. Many of these will be the channels of impressions and impulses between the nerve-nuclei along the floor of the fourth ventricle and the sensory and motor ganglia of the brain; possibly some may arise in the cells in which the fibres of the crura cerebelli end. However this may be, it is evident that there are masses of fibres in the crus which have not come up from the cord, and which do not, consequently, belong to the motor or sensory channel of the cord.

In the crus, the sensory and motor tracts are for a time separate and distinct, and form the *tegmentum* and *crusta* respectively, the locus niger lying between them. The *crusta* is inferior and superficial, and is seen at the base of the brain; the *tegmentum* lies upon it; but, while the motor tracts (*crustæ*) diverge, leaving between them the interpeduncular space, the sensory tracts (*tegmenta*) remain in apposition up to the third ventricle. Passing upwards towards the brain, the fibres of both *crusta* and *tegmentum* spread out fan-fashion, and, in doing so, change their relative position. The *tegmentum*, from resting upon the *crusta*, gets to its inner side; and the double fan formed by the two has its edges forwards and backwards. Its inner surface, formed by the *tegmentum*, is convex, looking inwards and upwards towards the ventricles, and has resting upon it the thalamus and intraventricular corpus striatum (caudate nucleus). Its outer surface is concave, and looks downwards, having in contact with it the extraventricular corpus striatum (lenticular nucleus). The anterior edge of the *tegmentum*-fan overlaps the fan of the *crusta*, and bends completely round it near the anterior perforated space to reach the extraventricular corpus striatum.

The thalamus is chiefly intraventricular, and rests on the inner surface of the radiating fibres of the *tegmentum*; but it bends round the posterior edge of the fan-like expansion of the crus as a whole at the top of the descending cornu of the ventricle, this process sending fibres backwards round the cornu to the occipital lobe, and forwards along the roof of the cornu. The thalamus exhibits, when hardened, an admixture of cells and fibres, and appears to resolve itself into masses of fibres proceeding forwards, outwards, and backwards into the hemisphere with those of the crus, those which pass forwards going beneath the intraventricular corpus striatum.

The corpus striatum may be said to sit astride of the anterior edge of the fan formed by the crus, and it is above as well as in front of the thalamus. The two portions of this ganglion, the intraventricular or caudate nucleus and the extraventricular or lenticular nucleus, approach each other near the anterior perforated space, but are scarcely continuous; their grey substance, however, is continuous between the diverging fibres of the corona radiata. The grey matter is soft, and shows little intermixture of fibres. There cannot be traced from the intraventricular portion any great masses of fibres passing to the hemi-

Fig. 7.—Transverse section of Brain behind Infundibulum. Sv, Intraventricular; and Sx, Extraventricular Corpus Striatum. Th, Thalamus. Cr, Crusta; and T, Tegmentum of Root, or Crus Cerebri. R, Radiating expansion, or Corona Radiata. Cx, C, and R together, form what has been called the internal Capsule of the Lenticular Nucleus. Cx, External Capsule (including the Claustrum). C, Corpus Callosum. FS, Figs of Sylvius. LMG, Longitudinal Marginal Gyrus. SMG and SMG', Sylvian Marginal Gyri. . . . indicate line of distribution of fibres of Corpus Striatum. . . . fibres of distribution of Thalamus. Left side of figure more accurate than right.

spheres, though fibres pass round in the roof of the middle or inferior cornu of the ventricle from its posterior caudate extremity; nor can fibres of the crus be traced to it. This is probably, therefore, the less

important division of the ganglion; an additional reason for this conclusion being, that it dwindles greatly in relative size during the development of the hemispheres. At an early period, it appears like a great roll of grey matter extending from the anterior extremity of the ventricle round the whole length of the descending cornu. Considerable mischief, again, may take place in it without giving rise to hemiplegia. The extraventricular corpus striatum is encased on its outer surface, which lies immediately beneath the convolutions of the island of Reil, and on its inferior surface, by a thin layer of fibres arising in the cells of its grey matter, these fibres passing to the convolutions of the hemisphere; but most of its fibres must issue from the part of the ganglion which is in contact with the radiating fibres of the crus, and assist to form the corona radiata. The plane of fibres limiting the grey matter of the corpus striatum externally, and separating the ganglion from the gyri operi, has been called the external capsule—a name which would be unobjectionable if it had not led to the name internal capsule being given to the mass of radiating fibres which enter the region of the central ganglia inferiorly as the crus, and emerge greatly reinforced as the corona radiata, to be distributed to the hemispheres.

The point of interest here is the relation between these sensory and motor tracts and the central ganglia, the thalamus and corpus striatum. The corpus striatum is unquestionably the motor ganglion; and I assume (though it cannot be said to be demonstrated) that all the fibres of the motor tract from the cord and medulla end in it. It will be in the extraventricular portion that the fibres end, for the intraventricular part of the ganglion is separated from the crista by the whole thickness of the tegmentum. The thalamus I consider to be the sensory ganglion—a view not universally accepted; and I assume, again, that in it the sensory tract finds its terminus. Meynert considers that his sections of small brains of lower animals show this, as well as the termination of the motor tract in the corpus striatum. I am bound to add that, in my own dissections of the human brain, the thalamus has been easily raised from the tegmentum, as if not closely connected with it; but naked-eye dissections cannot be at all relied on to determine the relations between cells and fibres; e. g., in a cord hardened in spirit, the antero-lateral white columns can be separated from the grey columns in which their fibres end, as if they had little or no connection with each other. There are fibres in the crus which, according to my observation, do not end in the central ganglia, but pass by them to the hemispheres; but, as has been mentioned, the crus contains other fibres besides those of the sensory and motor tracts, either coming direct from the cerebellum or from cells in the pons, etc., with which cerebellar fibres are connected.

Another point of interest is the connection between the thalamus and corpus striatum which ought to exist if they are the sensory and motor ganglia, and especially if the sensory and motor nuclei of the cord and their relations furnish any guide. The required connection is easily demonstrated, and is found to consist of fibres issuing from the thalamus and entering both divisions of the corpus striatum. The thalamus, which, as has been said, can be raised posteriorly from the tegmentum, gives off from its anterior and outer margins in relation with the intraventricular corpus striatum large round bundles of fibres, which follow the direction of the radiating fibres of the tegmentum. These, proceeding forwards, pass beneath the intraventricular corpus striatum, the soft grey matter of which dips in between the bundles. The extraventricular corpus striatum is not so easily reached, both tegmentum and crista separating it from the thalamus. Fibres, however, from the latter ganglion find their way to it round both the anterior and posterior edges of the fan-like expansion of the crus. It has already been mentioned that, anteriorly, fibres of the tegmentum turn round the edge of the crista, to end in the external division of the corpus striatum (*rt*, Fig. 8). With these are others from the thalamus. Posteriorly, again, the thalamus curves round the crus, and ends in a tail-like process (*th*, Fig. 8), which passes forwards in the roof of the descending cornu of the lateral ventricle; its fibres forming part of the collar of the crus, and passing to the grey substance of the extraventricular corpus striatum beneath the uncinate lobule.

We come now to a consideration of the function of these ganglia. The corpus striatum is the motor ganglion for the entire opposite half of the body. It translates volitions into actions, or puts in execution the commands of the intellect; that is, it selects, so to speak, the motor nerve-nuclei in the medulla and cord appropriate for the performance of the desired action, and sends down the impulses which set them in motion. These impulses are transmitted through fibres, and the fibres must start from cell-processes in the corpus striatum. *A given movement, therefore, must be represented in the corpus striatum by a group or groups of cells giving off downward processes, which become fibres of the motor tract of the cord.* When the movement is simple, or when the co-ordination required can be effected by the cord,

as in walking, the cell-group will be small, and the descending fibres few. When the movement is complex and delicate, and guided by vision or by conscious attention, as in writing or drawing, the cell-groups

Fig. 8.—On the right side, the dissection has only been carried far enough to show the plane of fibres underlying the superficial convolutions on the inferior aspect of the Temporo Sphenoidal Lobe, and forming the floor of the descending Cornu. This Cornu has been opened anteriorly, and fibres (*sx*) from the Extraventricular Corpus Striatum to the apex of the TS Lobe are seen. On the other side, the dissection has been carried much further, and the optic tract has been removed. *rr*, Crus Cerebri; *rc*, Crusta; *rt*, Fibres of Tegmentum (and from Thalamus), turning round anterior edge of Crusta; *th*, Tail of Thalamus turning round posterior edge of Crusta, forming Collar of Crus (*Panse du pedoncle*—Gratiolet), and distributing fibres to Sylvian margin of Temporo Sphenoidal Lobe; *th'* and *sx'*, Fibres from Thalamus and Extraventricular Corpus Striatum respectively to occipital extremity of Hemisphere. The longitudinal fibres not indicated by letters belong chiefly to the System of the Gyrus Uncinatus.

will be large and definite, and the descending fibres numerous. There will not be a separate group of cells for each movement; but the same cells may be differently combined, just as different combinations of carbon, hydrogen, oxygen, and nitrogen, form the basis of all organic substances. Words which require for their utterance the simultaneous co-operation of muscles of the chest, larynx, tongue, lips, etc., and the exquisite and rapid adjustment of their movements concerned in phonation and articulation, must be represented in the corpus striatum by very large groups of cells, and not in that of one side only, but in both.

That the thalamus is the sensory ganglion is by no means generally admitted. Experiments have appeared to give contradictory results; but complete experimental destruction of the thalamus, without damage to other parts, has so often been shown to cause loss of sensation, and pathological lesions of this ganglion are in my experience so constantly associated with impaired sensation, that I cannot doubt that the thalamus holds a similar relation to sensation to that of the corpus striatum to motion. As regards experiments which seem to show that sensation is quite independent of the thalamus, we must bear in mind that some experiments would almost seem to warrant the conclusion that sensation, motion, and intelligence were all independent of the brain.

In a paper of mine already alluded to, I attempted to meet one objection to the sensory function of the thalamus; viz., that lesion of it is not attended with impairment of sensation to the same degree that motor paralysis follows injury of the corpus striatum; and I still think the explanation there given of this fact valid. For some reason or other, sensation is more diffusely conducted than motion. If we divide the ulnar nerve, sensation is not absolutely abolished in the ring and little fingers. It seems as if there were a general network of sensory nerve-fibres at the periphery, with outlets along the different nerves. In experiments on the cord, again, it has been found that, so long as the smallest bridge of grey matter remains, sensory impressions are transmitted; and it is well known that, in disease and injury of the cord, sensation often persists when motor power is entirely lost. The thalamus then simply shares the property of the entire sensory apparatus, in giving little evidence of lesion.

Another objection I left unanswered, because the reply depended on

the establishment of the hypothesis of the association of motor nerve-nuclei; and I did not wish to compromise this by putting too great a strain upon it. The objection is that, if the thalamus be the general sensory ganglion, it should serve for the special senses as well as for common sensibility; and that, when lesion of the thalamus gives rise to hemi-anæsthesia, it ought to cause also unilateral blindness and deafness, which it does not. Now, if bilateral association of muscles be accompanied with bilateral association of motor nerve-nuclei in the cord, and this prevent paralysis of such muscles in hemiplegia, bilateral combination of sensation ought to involve fusion of sensory nuclei. It is unnecessary to point out how complete is the combination of the vision of the two eyes: scarcely less complete is combination of sound reaching the two ears. There ought, then, to be such close association between the two optic nuclei and the two auditory nuclei as to make them practically a single nucleus for the two nerves sending fibres to the two thalami; so that unilateral blindness or deafness, from injury to one thalamus, would be impossible. Dr. Hughlings Jackson has lately called attention to the occurrence of hemiopia with hemi-anæsthesia due to lesion in or near the thalamus. This appears to me to be the precise analogue of conjugate deviation of the eyes.

The function of the thalamus as the sensory ganglion will be to translate an impression arriving from the cord into a crude sensation. It is not easy to represent this in terms of cells and fibres, but it may be illustrated as follows. A finger is placed in the palm of a sleeping infant; the little hand closes gently round it. This is simply reflex. (Poor old Kentuck, in Bret Harte's story of "The Luck of Roaring Camp", would scarcely have been so excited by this simple act, had the scientific explanation of it been present to his mind.) Let the child be awake, and it will be vaguely conscious of the pressure, temperature, surface-characters, etc., of the object, but as feelings only, and without any knowledge of the external cause of its sensations. This gives roughly an idea of the office of the thalamus: it is a stepping-stone between impressions and perceptions.

An example of the automatic actions effected by the thalamus and corpus striatum (the parallels of reflex actions of nerve-nuclei) will be the involuntary shrinking from a blow and the instinctive attitude of defence. The latter is none the less automatic at the moment for being "scientific" and the product of long education and training. It is not antecedently realised in consciousness; and just as the cell-and-fibre apparatus in the cord concerned in standing and walking, once educated, acts automatically, so does the more complex apparatus in the sensori-motor ganglia. When a man would put up his arm, a woman might not improbably simply scream: the one and the other may be equally automatic. But we shall come to kindred subjects again.

[To be continued.]

NOTES ON WHOOPING-COUGH.

IN two cases of whooping-cough lately under my care, the phenomena preceding the spasmodic attacks were so peculiar, that I venture to think they may not be without interest to the readers of the JOURNAL. In the first, that of a delicate strumous-looking girl aged 11, the attacks were preceded by suffusion of the eyes and intense epigastric irritation, and could generally be checked by rubbing the epigastrium briskly. Later on in the disease, each attack finished with two distinct sneezes, instead of vomiting as before. (Trousseau mentions similar instances of this latter occurrence.) In the latter case, that of a female child aged twenty months, with a pale pasty complexion, each attack was preceded by an irritation in the right hypochondrium, which caused her to put her hand on the spot, and exclaim that a flea was biting her. The point of interest in these cases is, that the organs irritated—in the one case, the stomach, and in the other presumably the liver—are supplied by terminal branches of the pneumogastric nerve, for which the specific virus of the disease seems to have a special affinity. Another point of interest in the first case is the strong similarity between the epigastric irritation and an epileptic aura (which, moreover, is sometimes visceral), and the analogy is more striking when we remember that an epileptic attack may sometimes be checked by firmly grasping the part whence the aura proceeds. This is interesting, as bearing on the subject of the correlation of nervous disease, on which Trousseau touches in his lecture on Epilepsy. I may mention that, in this case, there was a well marked ulcer of the frænum lingue, an appearance which a recent French writer, M. Bouchut, considers pathognomonic: an opinion, however, with which my own experience does not accord.

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CLINICAL LECTURES ON MOVABLE BODIES IN JOINTS.

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LECTURE III.

I WILL now relate three cases of excision from the knee-joint of movable bodies; in each the substance was of a different nature; and, as each case has its peculiarity, I will preface them separately by a few short remarks pertinent to their special aspects, while their teaching collectively will be considered in the sequel.

The first case is that in which a bony growth was removed by direct excision after a previous vain attempt to remove it subcutaneously. The history is remarkable, inasmuch as the appearance of this "joint mouse" immediately followed an injury; yet it formed no normal part of the joint-surface. This should be a warning against concluding, as some have done, that such bodies as make their appearance shortly after an accident must of necessity be portions broken from the constituents of the articulation.

CASE 1.—C. H., aged 43, a retired army-surgeon, came into my room on July 21st, 1875, and reminded me of his having consulted me in 1872 on account of pain and difficulty on moving his right knee. He further reminded me that I, finding him in a very rheumatic condition, had counselled a residence abroad, and that I had mentioned the proclivity of his then condition towards forming one or more false bodies in the affected knee. I remembered as he mentioned, it having been impressed by the peculiar rough condition and the grating of his synovial membrane.

He gave the following history of his condition at the above date. In the last week of May, he tried to get into a carriage of the Metropolitan Railway whilst it was in motion. He struck his knee sharply, and was thrown back, with some violence, upon the platform; got up quickly, and out of the way, fearing to be taken in charge. The next day he found a loose body in the knee; he had no synovitis or pain. He also said that, after this accident, he missed a lump which he previously had over the inner condyle.

I found the body easily at the time, and on several subsequent occasions; it had no fixed residence, but, by certain movements of the limb, he could usually bring it into view. It appeared somewhat rough, hard, and about the size of a horse-bean. It could be moved into almost any part of the knee, but most easily into the subcutaneous sac. As a merely temporary expedient, I fastened it in that situation with pad and strapping. It remained stationary after this for a day or two, then slipped away, and caused a good deal of pain. Though he had never had a violent seizure, the annoyance was so considerable, and, being a nervous person, the dread of such an attack was so troublesome, that he greatly desired removal of the body.

July 10th. I got the body into place where it could be best fixed—viz., above the outer condyle—and operated after Square's method, but the body would not pass out; it slipped away, and could not be found.

July 17th. No bad symptoms had resulted, and, prior to opening the membrane, I made an attempt to fix the body with a Glover's needle in a properly constructed needle-holder. I found it so hard that it was impossible to introduce the point. I declined to attempt subcutaneous removal, fearing another failure under these conditions.

July 31st. He was determined to have the body removed; and I operated at the place where the body could best be fixed, viz., above the outer condyle, with considerable shifting of the skin, and perfect exclusion of air, with instruments well cleaned with carbolic acid. The body would not come of itself from the joint, and I had some difficulty, owing to its roundness and hardness, in getting any forceps to hold it; but, after a little, I succeeded in extracting it, the edges of the wound being held close behind the body, so as to obviate any entrance of air. It was stitched, painted with collodion, and, when this was dry, covered with cotton-wool; the limb was then placed on an Amesbury's splint. Barely any swelling took place; the part remained free from pain, though slight tenderness round the wound could, as might be expected, be discovered. In fact, I regarded the patient as convalescent; when, on the morning of the 8th August, I was sent for in great haste. I found that he had, feeling some slight pain the day before, discarded the warm applications that I, knowing his rheumatic tendency,