The special communications of the motive segments of the crus of the brain with the intellect : also, the separate parts of the brain producing the three voluntary powers of the muscles / by Joseph Swan.

THE

SPECIAL COMMUNICATIONS

OF THE

MOTIVE SEGMENTS OF THE CRUS OF THE BRAIN

WITH THE INTELLECT.

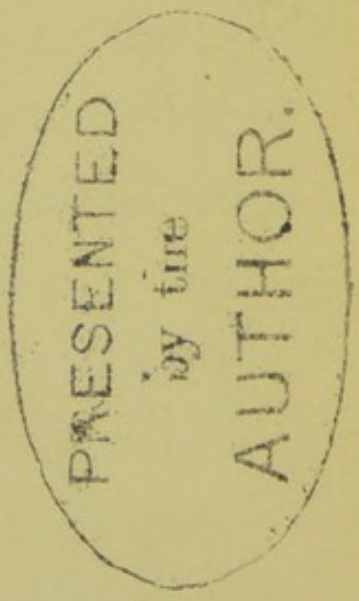
ALSO, THE

SEPARATE PARTS OF THE BRAIN

PRODUCING THE

THREE VOLUNTARY POWERS OF THE MUSCLES.

By JOSEPH SWAN.



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PREFACE.

In preceding publications the convolutions of the brain belonging to the sensitive, involuntary and true visual tracts were particularly noticed. It has now been ascertained that each of the convolutions placed more anteriorly in the same longitudinal or peripheric series through its tract forms an intimate connection with a particular division or segment of the crus of the brain. Such convolutions, however, from their situation, could not be considered as giving motive power to the tracts or segments forming the crus of the brain, but as contributing an additional or intellectual quality to them for co-operating with the voluntary motive. It became, therefore, necessary to institute a further inquiry by endeavouring to trace the segments of the crus of the brain to the convolutions of the exterior or motive region; but for a long

time any discovery of such a connection could not be made out. At length, however, the separation of the exterior region into layers, and of these into sections and tracts, was accomplished, whilst the tracts were found to be extended through the crus of the brain, the annular tubercle and the oblong medulla to the spinal cord. The dissection of several brains was then completed.

The anatomical description has been carefully drawn up, and with as much minuteness as seemed to be required for understanding the principal facts. Delineations of the several parts, with explanations, may be added, at a future time, if they are required.

As much difficulty was experienced in making the dissections from which the descriptions of the several parts mentioned in the succeeding pages were taken, it seemed probable that a short explanation of the proceedings might be useful to those desiring to make a practical investigation of the subject.

In previous dissections of the intercedent region of the brain, the convolutions and the great commissure forming the median region had been removed to the extent of the true visual tract, so that if the remaining

convolutions forming the anterior portion of the median region are taken away, the entire surface of the convolutions and tracts of the intercedent region may be seen. The foremost tracts tend towards the anterior edge of the thalamus, but before their terminations in the segments of the crus of the brain can be entirely separated and made clear, the anterior angle of the thalamus, with the mammillary body, the optic nerve, and part of the optic tract must be removed.

When the intercedent region has been entirely taken away, the inner surface of the exterior or motive region becomes exposed. It forms a nearly even surface, but the fibres comprising it have a peculiarly interrupted or contorted appearance, so that there is a marked distinction between it and all the other parts of the brain. Repeated trials to trace single convolutions by their tracts directly to the crus of the brain had never succeeded, and as this surface for a long time seemed to be without any decided lines of separation, no guide existed towards finding out the uses of its several regions. In the hemisphere of a brain hardened by spirits, and from which the median and intercedent regions had been removed, and after frequent examinations, and probably

from its having thereby become somewhat dried, a mark of separation on the surface was observed. It was found by the use of a large flat couching needle that the separation extended in the plane, so that broad layers were formed which received the fibres proceeding from several convolutions. The first line showing a discontinuation of the surface lay between the most anterior point of the exterior region and the crus, and it was found to be the separation between the inner and intermediate layers, which appeared to be placed one over the other, the latter commencing more forward than the former. The inner layer was followed to its full extent, and after its removal the whole of the intermediate layer was made manifest, and by its removal the outermost layer became apparent; all the three layers, their sections and tracts, are particularly described in the succeeding pages.

It is necessary to remove the involuntary tract from the centre of the oblong medulla before the motive tracts are traced through the crus of the brain, likewise the sensitive tract forming the floor of the fourth ventricle, with the thin outer layer of the restiform body. It is also required that the thalamus should be removed,

but its white surface and the grey matter connected with it should only be taken away; the rest of the grey matter forming the bond of unison between the extreme fibres of the motive tracts and the crus must remain, otherwise the precise connections are not properly preserved. By these proceedings there will remain only the motive region and the connection of its tracts with those of the cerebellum, and their continuations, which are described in the work.

6, Tavistock Square,
November, 1862.

THE SPECIAL COMMUNICATIONS OF THE MOTIVE SEGMENTS OF THE CRUS OF THE BRAIN WITH THE INTELLECT.

EACH hemisphere of the brain is formed into three peripheric or longitudinal regions; the median, the intercedent, and the external.

The median region occupies the convolutions placed near the middle line; its superior surface extends outwardly as far as its convolutions are combined with the corresponding ones of the opposite hemisphere by the great commissure. Its convolutions do not receive tracts from any organ of the body, and therefore are well qualified for ministering to the highest faculties of the intellect; and as they are only approached by the convolutions of the intercedent region and the great commissure and its processes, the perceptions reaching them become thereby modified for acting with the intellect.

The intercedent region is placed between the median and external; its convolutions are connected with the tracts of all the cerebral and spinal nerves, and occupy the whole length or periphery. The first or most

anterior convolution gives origin to the olfactory nerve. The tract of the second anterior convolution passes to the fifth, or most posterior segment of the crus of the brain, terminating in the oblique layer of the annular tubercle, which gives origin to the smaller portion of the fifth nerve; the hard portion of the seventh and the ninth, for modifying the functions of the muscles of the nose, ear, face, tongue, and throat. The tract of the third anterior convolution passes to the fourth segment of the crus of the brain, tending to the nerves of the upper extremity. The tract of the fourth anterior convolution passes to the third and second segments of the crus of the brain, tending to the nerves of the lower extremity and spine. The tract of the fifth anterior convolution passes to the first segment of the crus of the brain, for modifying the origins of the third nerve, and by its extension through the annular tubercle for modifying also the origin of the sixth nerve; and it cannot escape observation, that this convolution, which is next anterior to that of the true visual, is often seen intimately grouped with it, the one ministering to the functions of the optic nerve itself, the other to two of the principal nerves of the muscles of the eye. Five convolutions before that of the true visual have been enumerated, but there are sometimes six. The next succeeding convolution, which is the sixth, descends to be inserted into the anterior part of the thalamus and

the mammillary body, and forms the true visual tract; further back the seventh convolution terminates in the involuntary tract; and still more posteriorly, the several convolutions belonging to the sensitive functions. The tracts forming the restiform body do not communicate with the intercedent region, they have therefore principally animal voluntary functions, when they do not act in subservience to other parts.

When the communications of the motive segments of the crus of the brain with the anterior tracts of the intercedent region, in connection with those of the sensitive and involuntary tracts, are considered, it must be concluded that the functions possessed by the external region are of themselves only consistent with the conveyance of simple voluntary impulses. The will, in effecting ordinary motions, partakes in some degree of the general guidance of the intellect, but any higher powers must pass by a special arrangement of fibres. The intellect itself requires a particular structure for its own uses, and an intercedent one for allowing its special communications with the voluntary motive, the involuntary and sensitive tracts.

As the anterior convolutions of the intercedent region give additional powers to the motive functions, in like manner, the true visual, the involuntary and sensitive, derive a high sensorial quality from the more posterior ones, for enhancing their functions in the completion of

the perceptive faculties. They may also convey power from the intellect to the nerves and organs, and prepare them for their required activity, by imparting the tonic quality when their attention is required.

Although the convolutions of the intercedent region are connected with cerebral and spinal nerves which have different functions, the whole receive the same high sensorial power. But it may be presumed that the anterior convolutions become more energetic from the greater thickness of the superincumbent grey matter of the striated body connected with them. Their high sensorial qualities prepare them for acting with the intellect, when it is specially required in directing particular muscles for adding mental qualities to the physical—as for speaking or singing, for writing or drawing, or for animating the features, and promoting particular attitudes of the body. The muscles are also concerned in the consummation of the sensitive functions. The influence, therefore, of the intellect communicated through the intercedent tracts to the voluntary crossing ones, only resembles a more complex act of the will for directing the muscles to produce speech instead of vague sounds, and writing or other accomplishments, instead of ordinary motions.

In animals there are only two convolutions anterior to that of the true visual tract, and one of them invariably descends to the part of the crus giving origin to the

third nerve; and by its continuation through the annular tubercle, also to the sixth nerve. The large contribution to all the nerves of the muscles of the eye, except the superior oblique, shows that the motions of the eye are more under the influence of the intellect than those of any other organ. The anterior convolution, which is the smallest, passes outwardly across the crus of the brain, and is then continued downwards within it in the horse and ox; and having arrived at the transverse tract forming the trapezoid body, it becomes connected with the origin of the smaller portion of the fifth, and further down with the hard portion of the seventh; it is then continued further down to the origin of the ninth. It is probably destined for such of the motive parts of the face, nose, mouth, and tongue, as are required for completing the expression of the passions, and for modifying the cries peculiar to any animal in accordance with its propensities.

As there is a much greater extent of the convoluted surface in the median region of the human brain for acting with the intellect than in animals, it may be concluded that its proportionate range in the intercedent region exerts an equivalent influence over the motive and sensitive organs, for allowing the inventive and mechanical powers of man to be evolved and exercised in connection and correspondence with other mental operations. The inferiority of the brain of animals is

generally commensurate with a more circumscribed power of the intellect, and although its size is generally compatible with a vast increase in the proportion of the muscles and skin, and consequently a greater cumulative force than the human, its more limited intellectual co-operation with the motive and sensitive organs is in conformity with the partial contrivances and expediencies which exist as marks of the propensities of lower creatures, it also corresponds with the inability to turn the brute force to any other account than for locomotion and the collection of food, unless it has been previously trained through the superintendence of man.

It must be remarked, that the tracts forming the restiform body in man do not communicate with the intercedent region, and there is not a convolution for it in the intercedent region of animals. It is, therefore, placed in the same condition as the greater part of the motive region in animals. As the restiform body in man approximates to the same part, and to the motive region generally in animals, it is lower with respect to the intellect in man than any other portion of the motive region, and is fitted for carrying out the commands of the animal will entirely.

By the influence of the mind through the intercedent region there is not only the varied play of the facial muscles and the expression of the eye, but the lips,

tongue, mouth and glottis are brought into harmonious activity for perfecting the voice, speech and singing. Through their modified activity the expired air is made to issue for the formation of words, or other expressive sounds, and the muscles of the chest have been constituted for according with these actions. In animals the difference of the nose, and the frontal and other sinuses connected with it, the mouth, throat, and glottis, and facial muscles produce the modifications of natural sounds, and their several degrees or powers of expression can be manifested in the more calm states of the countenance, but become particularly striking in agitations through the passions. All these are effected by the intellect through the intercedent region, and when voluntary powers are added for making the acts of inspiration and expiration very forcible, the mouth and throat are prepared for acting with them. By the forcible expiration sounds become loud; the different kinds of sounds are modulations of the motions of the mouth and other parts, but the degrees of loudness proceed from the will, and the force of the animal passions, and partake very little of the calm activity of the intellect. This great increase of voluntary exertion takes place through the restiform body, and as its tracts have no communication with the intercedent region, it is a mere exercise of the will and animal passions. Loud speaking and singing

partake of this forcible character, and the greater the degree in which it is exercised the less the intellectual qualities accompany it; for in the formation of any forcible voluntary motion, the mind is not at the same time capable of any graceful and moderate exercise. Loud speaking, therefore, or singing, or any animal sounds, resemble the impetus given to wind instruments for expelling the air with vehemence, but prevent or render nugatory any gentle or nice touch or activity of the fingers, or lips or glottis, according to the manner in which they are moderated by the mind under gentle acts of expiration. The mere relaxation of the inspiratory muscles and the subsidence of the chest are not sufficient for producing crying or other natural sounds, and certainly not for speech; the motions of the muscles of the mouth and tongue may form the words, but a voluntary expiratory assistance must be added.

It has been long understood that the mere animal functions, both of the voluntary muscles and the sensitive organs, are separate from the intellectual qualities, so that after paralysis, when the powers of voluntary motion have been restored, those proceeding from or acting with the intellect have remained useless. In this manner, after the restoration of the voluntary motions of the lips and tongue, the loss of speech has continued.* Dr. Abercrombie is of opinion that the inability to speak

* Cooke on Palsy, p. 50.

does not always depend upon a paralytic affection of the tongue. In the loss of speech which accompanies many paralytic affections, he thinks there is something singular, "as it is quite distinct from mere palsy of the tongue." "A man whom I attended in an ordinary attack of hemiplegia, eighteen months ago," says Dr. A., "recovered the use of his limbs after a short time, so that, his intellect being quite correct, he was able to follow his employment, which is that of a collector of taxes. He has never recovered his speech, however, in the smallest degree, although he has every motion of the tongue perfectly, and of the lips—every motion in short that is required for forming letters; and he can make a sound, showing that the functions of the larynx are unimpaired; but he never attempts anything like an articulate sound. His understanding also is entire, and he has not lost his knowledge of written language, as appears from his management of his business. What is it then," says Dr. Abercrombie, "that he has lost?"

THE SEPARATE PARTS OF THE BRAIN PRODUCING THE THREE VOLUNTARY POWERS OF THE MUSCLES.

The external region is placed on the outer side of the intercedent, and is formed of convolutions as centres for giving voluntary power to the motive nerves. It has two surfaces: the inner one is in contact with the intercedent region; the outer surface is that of the convolutions. It consists of three layers of convolutions, divided into separate sections and tracts. The first or inner layer extends over a great portion of the inner surface, from which the intercedent region was removed. The second or intermediate layer is placed underneath and on the outer side of the first or inner layer, and is not so extensive. The third or outermost layer, with the convolutions attached to its surface, occupies the remainder of the exterior region, and is the largest of all.

The first or inner layer is divided into four sections: the first or most anterior section is large; it becomes concentrated into a tract for joining the superior pedicle of the cerebellum; it passes down just anterior to part of the sensitive tract, and reaches the inner half of the

restiform body. More posteriorly, the second section of the inner layer is placed; its tract passes downwards to the fourth segment of the crus of the brain. Next in the posterior lobe is the third section; its tract passes forwards at the inferior margin of the oval receptacle, and is continued just behind the anterior commissure, through some of the anterior fibres of the striated body, to the third segment of the crus. Next, the fourth section of the first layer in the posterior lobe sends off its tract to pass at the inferior margin of the oval receptacle, and be continued behind the anterior commissure, through some of the anterior fibres of the striated body to the second segment of the crus.

The first section of, or in a line with, the intermediate layer anteriorly descends by its tract to the first or anterior segment of the crus for the origin of the third nerve, and is continued through the annular tubercle to the origin of the sixth nerve. Next lies the principal section of the intermediate layer; it passes underneath the first section of the first or inner layer to the fifth or most posterior segment of the crus, and then through the most posterior layer of the annular tubercle for giving origin to the smaller portion of the fifth, the hard portion of the seventh, and the ninth nerves.

The third or outer layer anteriorly contains the section whose tract descends to the third segment of the crus with the tract of the third section of the

first or inner layer situated in the posterior lobe. Next, the tract of the second section passes down with the tract of the second section of the first or inner layer to the fourth segment of the crus; and, still more posteriorly, and forming the posterior margin of the middle lobe, the tract of the third section of the third layer passes down in the oblique tract placed between the anterior pedicle of the cerebellum and the posterior segment of the crus of the brain to join the posterior pedicle of the cerebellum and form the outermost half of the restiform body. The fourth section, which includes the remaining portion of the outer layer, and occupies the surface of the posterior lobe and of the lower part of the middle lobe, is continued forward in a tract at the lower margin of the oval receptacle, and, passing in front of the anterior commissure, joins some of the anterior fibres of the striated body, and then enters the second tract of the crus.

For convenience, the crus of the brain has been divided into five segments. The first or most anterior contains the origin of the third nerve, and, by the continuation through the annular tubercle, the origin of the sixth nerve. The second is next, and contains a tract from the posterior and inferior part of the first, and the fourth section of the third layer. The third contains the tract from the third section at the posterior part of the first layer, and the tract of the first section of the

third layer. The fourth contains a tract from the second section of the first layer, and one from the second section of the third layer. The fifth contains the termination of the tract of the intermediate layer for giving origin to the smaller portion of the fifth, the hard portion of the seventh, and the ninth nerves. As the second, third, and fourth segments are each composed of two parts, the entire crus, in reality, consists of eight segments. Besides these, an inner and outer tract exist for forming the restiform body; the inner proceeds from the first section of the inner layer of convolutions; the outer proceeds from the third section of the outer layer.

The restiform body occupies a somewhat similar position at the outer side of the oblong medulla as the glosso-pharyngeal nerve, the par vagum, and accessory. It appears to be composed of two structures: an exterior one, which is very much the thinnest, and is continuous with that forming the floor of the fourth ventricle, and when separated from the more interior or voluntary portion, carries with it part of the auditory nerve. The interior portion of the restiform body has two divisions or tracts; the more median one originates in the first section, which is the most anterior portion of the inner layer of convolutions, and, having received the superior pedicle of the cerebellum, is continued downwards towards the spinal cord. The outermost portion or tract of the restiform body proceeds

from the third section or outer layer of convolutions, and is continued downwards as the oblique tract placed between the superior pedicle of the cerebellum and the fifth or most posterior segment; it is then joined by the inferior pedicle of the cerebellum, and conveyed towards the spinal cord. The intimate texture of the large or more interior portion of the restiform body may be resolved into transverse fibres, which pass forwards to meet others from the anterior pyramid, and thus may impart its special powers to the flexor muscles taking part in inspiration, and to the extensor muscles taking part in expiration. The origin of the fourth nerve reaches the oblique tract of the outermost portion of the restiform body.

The preceding description has been confined to the arrangements of the sections and tracts of the layers constituting the exterior region; the succeeding observations relate to the several parts which have been mentioned in connection with their uses. Although the exterior region has so large a surface, and is connected with so many convolutions, yet there is great order and an apparent simplicity of design, and any seeming complexity tends to the explanation of the functions of the whole. The several layers are distinct, and their sections take separate courses, and are so connected or brought together through particular segments of the crus of the brain, the annular tubercle,

the oblong medulla and restiform body, that there is an apparent meaning in the concurrence of separate tracts of the inner and outer layers at their appropriate segments of the crus of the brain. In this way different kinds of nerves and plexuses originate at their respective centres, but meet together before they are distributed by branches on different structures. Before proceeding further it will be necessary to mention briefly the condition of the skeleton, and the kind of motion of the muscles adapted for different parts, and the peculiarity of the motive centres necessary for conveying to each of them the voluntary excitement for bringing them into action.

The principal portion of the muscles supplied by nerves issuing from the intermediate layer are attached to fixed bones, and the rest to those whose motions are very limited. On this account one kind of motion alone serves for all the muscles, as extensor powers are not required for producing opposition, which might have been necessary if the bones giving origin to the muscles had been loose and had allowed very free motions like the joints of the limbs. As the skeleton permits free flexor powers, and especially of the limbs, the body could not be kept upright and particularly the limbs, which could not support the body, unless there existed extensor powers for the purpose. There must therefore be muscles for bending the spine, and others

for opposing the flexion, and they must be much more powerful for keeping it upright; there must be muscles for bending the lower extremities and others for extending them and keeping them upright, and their motions must be so combined that the upright posture shall not be endangered. There must be similar powers for the flexion and extension in the neck, thorax, and upper extremity. Such opposing actions can only be completed by different ranges of muscles supplied by their proper motive centres according to the construction of the skeleton of man; if there had been only one source of motive power like that produced by the intermediate layer, the present free motions could not have been allowed; for this reason, and for keeping the bones and joints in the states of flexion and extension, in any position requiring mutual activity, two separate kinds of motive centres are necessary, which are distinct in origin, but capable of modifying their respective powers of agency, for allowing the two kinds of muscles to co-operate through the nerves combined by simple coalition or by plexuses, and produce the interchanges of action necessary for firmness and steadiness of motion.

The intermediate layer is placed between two others; it has only one motive power and is not connected with any others. Each of the other layers has also its single motive power; but there is this difference, inasmuch as

it is made to co-operate with the other almost continually. Two distinct powers are required for corresponding with two different sets of muscles, the one for flexion, the other for extension, and the layer appropriated to each is divided into sections, and each section terminates in a tract. The tracts of either layer do not become combined into a single column in their course to the spinal cord, but a tract from each layer meets together to form a separate pair, and each pair passes through the crus and the oblong medulla to the spinal cord, and one pair only through the oblong medulla alone to the spinal cord. There are therefore four distinct pairs of such tracts entering the spinal cord and giving off their respective nerves. The first pair is for the flexors and extensors of the spine; the second for the flexors and extensors of the lower extremity; the third for the flexors and extensors of the upper extremity, and the fourth for the flexors and extensors included in the restiform body. The fifth, which is the continuation of the intermediate layer, is excluded as it ceases at the termination of the annular tubercle in the oblong medulla.

Of the three layers the functions of the intermediate alone are distinct and entirely separate from any other.

The most anterior portion of the first or inner layer is very singular in its origin, and in its conduct to the inner side of the restiform body, and it is presumed that

it belongs to voluntary inspiration. The second section of the layer, which is contiguous to that forming the inner portion of the restiform body, and on many occasions is so much concerned with the respiratory acts, is appropriated to the flexors of the neck and upper extremity. The third section and tract, occupying the more anterior portion of the posterior lobe, is for the flexors of the lower extremity, and in contiguity with this the fourth section begins; it is derived from the lower part of the posterior lobe and from the middle lobe, and is destined for the flexors of the muscles of the spine itself, and those subservient to the viscera contained in, and connected with, the pelvis.

Of the third, or more exterior layer, the first section by its tract, joins the tract of the fourth section of the inner layer for opposing it, and producing the extension of the lower extremity; the second section joins the second section of the inner layer for opposing it, and producing the extension of the upper extremity; and the third section joins the tract of the first section of the inner layer, and forms the outer part of the restiform body, for opposing the inner layer for expiration. The fourth section, forming the whole of the posterior part of the third layer, passes to join the most inferior and posterior part of the inner layer for opposing it by actuating the extensor muscles of the spine itself.

The tracts for flexion and extension of the spine itself

descend to be connected with the most median portion of the spinal cord, next pass more outwardly those of the flexors and extensors of the upper extremity; on the outer side of these is the tract for inspiration, and then that for expiration, which is the outermost of all the tracts that have proceeded from the brain, the intermediate tract ceasing after it has given off the third and sixth nerves of the muscles of the eye, the small portion of the fifth, the hard portion of the seventh and the ninth nerves.

The several leading motions of the flexors and extensors are strictly confined to their own section of their respective layers of convolutions. It, therefore, seemed most consistent that the tract for inspiration should be next that of the flexor muscles of the upper part of the chest and arm, and those placed more posteriorly should be for the flexors of the lower extremity and spine; it also seemed probable that the tract for expiration, occupying a section, should be in the same layer or series as the tracts for the extensor muscles of the upper extremity and of the lower extremity and spine; and that the intermediate tract representing both of these properties should be placed between them. It was not, however, previously imagined, how the tracts of the posterior lobe were conducted to the more anterior part of the crus, and it forms the most curious part of the whole very interesting inquiry.

It will be thus seen, that the nervous roots in the anterior and lateral portions of the spinal cord, bounded by the denticulated ligament, and constituting the motive nerves arising from the spinal cord, are actuated by corresponding tracts proceeding from the sections of their respective layers in the exterior region of the brain. The more central tracts and nerves, therefore, belong to the flexor and extensor muscles of the spine itself; those placed more outwardly to the flexors and extensors of the leg, then those of the upper extremity and neck, then those for inspiration, which act most with the muscles of the upper extremity and neck, and the outermost of all those of expiration. On the posterior part the nerves belong to the sensitive and involuntary functions. The nerves appear to issue from the grey matter of the spinal cord itself, and be conducted through the white fibres in layers placed somewhat obliquely, for reaching each of the several tracts descending from the brain, and being then very delicate, are accommodated and sustained beneath the pia mater, just before they become fibrils, for collection into their respective nerves.

The convolutions belonging to any section of either of the layers by its tract form a regular connection with its respective range of muscles through the nerves, so that the will can direct any required motion, whether it be of a small part, or one more extensive, or of several parts at the same time. Some muscles have perfect

motive powers at birth, especially those supplied by nerves originating from the intermediate layer and tracts, and others promoting respiratory functions. But some of the functions of the intermediate layer, as well as those of respiration are only made perfect by the advancement of the intellect and by experience. The muscles actuated by the intermediate layer promote some motions which seem to be in opposition, as those concerned in opening the mouth to those shutting it; but the same nerves arising from the same layer are sufficient with a modification of the direction of the muscular fibres.

The intermediate layer gives origin to cerebral nerves which can be traced to their destination and have not any decided leaning either to flexion or extension, they seldom act by themselves on one side only at the same instant, but they must be always more or less engaged with those of the opposite side, either for simultaneous and corresponding actions, or for such as oppose or counteract each other; they therefore do not require more than one motive power for their functions. The qualities of the inner and exterior layers in the same precise manner cannot be so directly determined by the origins of the spinal nerves from them; their tracts are, however, only more lengthened than the intermediate layer, and in this respect differ from it. The nerves, indeed, must be first represented by tracts from which they arise

in the spinal cord, when from the small surface it will be found very difficult to recognise those belonging to each particular tract as plainly as the nerves can be found in the intermediate layer. Therefore, in attempting to point out which layer is for flexion and which for extension, there could not be so visible a proof derivable directly from the origins of the nerves, except the fourth, which arises from the tract leading to the outer portion of the restiform body, and gives opposing powers to the superior oblique muscle of the eye. The circumstance of the existence of two layers formed of separate sections, and the concurrence of a tract from one section of each layer at the several segments of the crus of the brain, corresponded so exactly with the muscles of particular districts which are known to be required to act as antagonists, that no doubt could be entertained, but that the two tracts passing from the brain and meeting together, had the two qualities necessary for the two powers of flexion and extension, and further on there will appear sufficient proof that the most exterior layer serves for the power of extension. Although the intermediate layer serves alone for the greater number of the muscles of the eye, and entirely for those of the face, mouth, and jaws, it is reasonable to conclude that for insuring quickness and precision in the motions of the larger regions of the body, flexion would be conveyed from one layer of the convolutions and extension from another, and their

functions be thus kept more distinct than if both had proceeded from contiguous convolutions in the same layer for every separate group of muscles concerned in similar motions. Each of the three powers, therefore, has a distinct range of convolutions, layers, sections, and tracts for its agency, and the two, although separated at their origins, are apportioned in sections and their tracts are ultimately approximated so that whilst they preserve their distinct qualities throughout, they also communicate them both separately to the respective ranges of muscles for producing opposing motions. By this arrangement, a few fibres of a section can excite the flexion or extension of a small part, as a finger, or, by the whole of two opposing sections, the muscles of an entire limb can bring it to a convenient position for its free use, or for securing its steadiness, or in giving it firmness for treading, and, with the spine, for supporting the whole body. Indeed, it is the economy in the origins of all the nerves, that each should have its precise place from which it derives its proper quality, however much it may be afterwards conjoined with others for compound functions, and it is only a part of the same economy that flexion or extension should proceed from its separate layer of convolutions, so that all chance of any premature or previous intermixture may be effectually avoided.

There is such a correspondence in the origins of

the nerves for the ordinary motions of the upper part of the body, and those of the restiform body, that the peculiarity calls for a few observations. The sections for ordinary motions generally act singly, and very often differently on either side; but those of the restiform body always act at the same time, so that the muscles of both sides are moved simultaneously for respiratory functions, and therefore do not interfere with the ordinary motions, except on special occasions. The agency of the respiratory muscles through the restiform body is forced by a pressing impulse, which is more strong than that for the ordinary motions through the will, and is generally connected with vital processes. Through the harsh perceptions of the involuntary tract, the sensory is admonished that delays in the circulation, or impediments to free respiration, require to be removed by a very deep inspiration, or anger or fear are to be gratified or appeased by the utterance of loud cries or sounds. When the restiform body acts, the ordinary motions are subdued or not attempted; if, therefore, in very gentle respiration the restiform body ever acts with the ordinary motive, it is by a permissive quality, for two strong impulses of the will cannot be accepted or entertained at the same time; but if they do co-operate, the several acts must be very moderate, and have been previously practised and combined by repeated trials.

The two sides of the neck may act either together or separately, also the two arms or the two legs. But the restiform bodies do not act singly unless in co-operation with the ordinary motions of the arm. The section of the inner portion of the restiform body is singularly placed alone, and may seem to have peculiarities proper for its purpose; that of the outer portion is the same as for the extensors of the arm or leg; their distinctness allows an entire and sudden action of all the parts they can influence together for uttering loud cries, also for coughing, sneezing, sighing and yawning, vomiting, and other expulsive efforts. The restiform body seems to have only the power of flexion like the limbs, and not in reality any power over respiration beyond its voluntary muscular one over the chest; but its efficiency is perfected through the strong perceptions of the involuntary tract, or of the sensitive tract, given to the sensory, which at once influences the will to bring it into activity.

It is remarkable that the extensor section of the spine occupies so large a portion of the posterior part of the exterior region, whilst that in the inner layer is so small for the flexor power; but both are in proportion to their required uses. It is, however, singular that the section giving the extensor power of the leg should arise from the anterior portion of the third layer, but it corresponds with the flexor section coming from the posterior lobe to join it anteriorly. It is also remarkable that the

extensor section of the upper extremity should be in the middle of the layer, and that for expiration be third, whilst in the inner layer that for inspiration is first. The situation probably does not make much difference in their respective properties and functions, so long as it is convenient for the exit of the tracts towards their final arrangement in the spinal cord. Further inquiry may, however, elicit the true reason.

The convolutions of the tracts for extension seem to preponderate over those for flexion; it is therefore probable that the efforts of the power of extension require a greater share of energy and attention than the flexors. In the infant the power of flexion is in the greatest activity, as it can creep quickly long before it can walk; the power of the extensors is long before it is sufficient for giving firmness to the spine and limbs for erect locomotion. The power of extension increases with the greater maturity of the convolutions terminating in the extensor tracts, and as greater energy and adroitness are necessary for balancing the body and sustaining the upright position during locomotion, and in continuing and varying such attitudes, the layer appropriated to the extensors has a larger share of convolutions for supporting its power. In the mere motion of smaller parts there may not be much difference, but a nearly equal balance between them.

It may appear that there is in reality only one exciting influence; its power may however be modified by passing from districts of convolutions and their layers differently constructed before their separate tracts are made capable of conveying it through the nerves to the muscles placed for producing opposing motions. The two tracts of the restiform body serve for respiration as an entire process, only that the inner portion or tract for inspiration probably influences the muscles of the neck and chest, which raise the ribs and excite the diaphragm, whilst the outer portion or tract influences the abdominal muscles, which by acting in opposition produce expiratory motions and assist in contracting the abdominal cavity for the evacuation of the viscera. The will may be conveyed in the same manner to other parts of the body for producing both flexion and extension according to a peculiarity in the arrangements of the convolutions and tracts for allowing the proper effects of each quality of motion through the muscles particularly constructed and placed. The intermediate layer serves for the peculiar motions of the eye, tongue, and face, and the muscles may be moved according to the direction of their fibres; but there is something more, otherwise the superior oblique muscle of the eye would not have needed a nerve from a different source, if the muscles only required the power of motion.

The third and sixth nerves are derived from a special

section and tract at the anterior part of the intermediate layer, placed between the two for flexion and extension; the tract is continued through some of the more anterior fibres of the striated body, and then passes to the most anterior segment of the crus of the brain, from which it is continued through the anterior portion of the annular tubercle, to give origin to the sixth nerve. The fourth being an opponent to that given to the inferior oblique muscle is placed alone, and probably by its connection with the outermost portion of the restiform body forming the expiratory tract derives its peculiar opposing powers. It is connected with the lachrymal nerve and the shedding of tears in the expiratory act of crying.

As the anterior fibres of the striated body receive the tracts which are to be continued from the anterior point of the middle lobe of the brain, and as the tracts proceeding from the convolutions forming the island have no other mode of communication than that near the junction of the anterior and middle lobes, it may be a question whether these convolutions receive from and convey high sensorial and perceptive properties to the lower part of the spinal cord and the nerves, directed to the pelvic viscera and their appendages. If such a communication take place through the motive tracts, it will only resemble that of the tracts from the intercedent region which join the segments of the crus of the brain for enhancing the power of other motive nerves.

The division of the exterior region of the brain into layers, sections and tracts, is in the highest degree convenient for allowing the properties and functions of each to be administered with precision for exciting the required kinds of motion of the muscles either in large or small groups; for the more gentle and intellectual uses or for the most energetic and mechanical operations and exercises. The same arrangement is most beneficial for obviating the spread of disease. It permits the morbid actions begun in any particular section to be confined there, and the symptoms thus partially produced to be often sufficiently premonitory for giving time, not only for curing the disorder, but for preventing its communication to neighbouring parts, or to other sections and tracts. From the previous anatomical descriptions it may be readily understood how the most extensive or the smallest group of convolutions may be paralysed or otherwise disordered. It may be seen how the small portion of the intermediate layer may be affected without implicating more than the motions of the eye, or spreading to any adjacent part, or how the larger portion of the intermediate layer may be attacked by disorder and its influence be confined to a paralysis of the lips, tongue or face, so that the speech and deglutition may be either partially or entirely impeded. It may be seen how a smaller or larger portion of any section may produce a confined or extended paralysis.

How an affection of the sections belonging to the restiform body may be connected with impeded or irritating respiratory functions, and be the precursor of, or the attendant on paralysis. It may be seen how an extravasation of blood may break up and otherwise injure all the layers of one hemisphere and produce a more or less complete hemiplegia, the symptoms varying according to the implication of the particular sections; also how an affection of the corresponding layers of the two sides may produce paraplegia, injury being done to one or more of the flexor sections alone, or of the extensor, or to both at the same time. When the flexor sections are most disordered, this motion of the trunk of the body and the extremities may be lost, whilst the power of the extensor sections remain; so that the body may be kept upright with a slight support, and all the other functions except those of flexion be well performed. Or the extensor sections may be the most disordered, and then the power of flexion remains the strongest, so that in walking it is necessary to use deliberation for keeping the body in the perpendicular by placing the foot at the precise distance, as the extensor sections cannot otherwise lend sufficient assistance for preventing an overthrow.

It may be seen why at the commencement of tetanus the jaws seem first to suffer, as there is very little opposing power in the muscles for relieving the morbid

contraction, and how the flexor and extensor muscles of the body generally may for a time by their alternating actions relieve each other, until the extensors from having the greatest power produce a complete opisthotonos.

When the free locomotion of low animals is observed, and the proportion of the brain to the body, it cannot fail of exciting a desire to know why the external region of the brain in the higher animals is so large, and particularly in man.

The extensive convolutions forming the exterior region in man are provided not only for giving motive power in proportion to the muscles, but for forming a part of the sensory, for giving him a high quality of motive power, and a superiority of carriage and appearance in the erect position especially, above all creatures. If man has an extensive source of motive power, it is difficult to conceive how the highest animals retain the activity of much larger ranges of powerful muscles by a smaller brain, and the more inferior by one so remarkably diminutive. The large exterior region may be presumed to give to the highest species of animals some similar properties to those possessed by man; but in creatures having a very small brain in proportion to a large body, with great locomotive powers, some other explanation seems to be required, and can only be found in the correspondence of the motive

intermediate layer would be the sole originator of all the voluntary motions.

The quality and properties employed in the terms of flexion and extension cause some difficulty in appreciating the motive actions. They exist together for a co-ordinate purpose, and then follow each other quickly, that the different muscles may produce firmness of the limbs for progression or other purposes; but one kind of motion alone may suffice when the bones and muscles are constructed for allowing the motions of the trunk only, and such smaller appendages as are not required to give it any support. It seems to be considered, that when a part is moved, a contrary motive or extensor power must be used for restoring it to its usual position; but this can be effected by mere relaxation of the motive effort, as when the mouth becomes open of its own accord, instead of by its proper muscle. By this adoption much more simple powers are made available, and can be used in various degrees, if not entirely, in numerous animals, and thus a smaller portion of the brain for motive centres becomes necessary. The form of the foot, and the pointed and lengthened toes, by laying hold of the ground, or by any other impeding properties, prevent the limb from slipping, and make a less degree of firmness to be produced by extensors necessary. The large elastic ligament in the neck and other modifications tend to the same end

If considerations like the preceding be not adopted, it becomes quite unintelligible how an animal, with from ten to twenty times as great a quantity of muscle as man, can have its motive powers capable of being always ready to be called forth in an orderly manner, through the diminutive brain according to the will. It would be a difficult task to point out with precision all the modifications of the brain in different classes of animals; but there cannot be a question about their existence, according to an exact rule for acting with parts adequately constructed for harmonising with them.

It would show a great deficiency of knowledge if it were presumed that the motion of the voluntary muscles was performed entirely through the will and the motive centres and tracts by muscles formed for acting on a skeleton, whether its joints were free or constrained. The agency of the will must be sustained by a spinal cord, which is large in proportion to the quantity of muscles. It must also be in conjunction with sensation and the involuntary power. In many low animals having a very small brain, the sensations during motion assist in a very marked degree to continue the motions, with only the assent of the will, the peculiar motive structures allowing it to proceed, but requiring the will to stop it. It would have been easy to introduce much interesting matter in relation to the auxiliaries of volun-

tary motion, but it was resolved to keep as much as possible to the functions performed alone by the motive centres and the muscles through the influence of the will.

THE END.

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region of the brain with the construction of the skeleton and the quality and extent of the actions of the muscles it allows. Although there be a great seeming power in the muscles of the large body of a low animal, it is of a more simple kind, and not varied as it is in the highest; instead of flexors and extensors, as in man, there probably exists only one kind of motion; so that in progressive exercises, first, the muscles of one side act, and by their relaxation those of the other succeed, or both sides at once may produce straightforward motions, or such as raise or depress the upper or lower half of the body. The skeleton is formed so that extension is not required when the flexors are relaxed: therefore, when the brain diminishes, two means of assistance are afforded, the principal one by the firmer or more compact condition of the skeleton, and the other by modified motions of the muscles. For such purposes, a centre of motion, like that afforded by the intermediate layer in man, might suffice. The principal portion of the muscles thus supplied are attached at their origins to fixed bones, and the rest to those whose motions are very limited. For this cause, the power of extension may appear not to have been needed, but to be only required when the joints are loose, and the muscles must counteract their movements by keeping the ends of the corresponding bones in such a state of apposition as will support the body, especially

when it is to be kept upright, and the limbs in this position are to be capable of wide or extensive motions. Some of the muscles supplied by nerves derived from the intermediate layer have an appearance of opposition, which might seem to require the additional quality of extension, but all the functions are performed without it. It may, therefore, be presumed that a similar source of motive power produced by modifications of the intermediate layer would suffice for all the ordinary motions in very numerous animals, provided additions were made for respiratory functions, sensation, and the intellect according to the required state and condition of each creature. When the skeleton is compact, and allows only a moderate motion of the several joints, it may be presumed that the motive centres may in quality resemble the intermediate layer, and then the inner and outer layers, for flexion and extension, as in man, would, in a great measure, if not entirely, cease to appear, whilst the brain and the spinal cord would be thicker or thinner for accommodating the required issue of nerves, according to the bulk and power of the muscles. The intermediate layer in man may be the type of the centre of voluntary motive excitement in all animals, portions of the inner or outer layers being added according to the higher standard in creation, and when the opposing powers of flexion and extension cease, there would remain no distinction, as the force corresponding to that of the