Thesis

on the

Spinal Cord

and its relation to

Muscular Contraction

by

Henry Steele.

Preface.

When I began to read with a view to writing a thesis, Epilepsy was the subject on which I proposed to discourse. It soon became evident, however, that to do so satisfactorily would be impossible, without having first of all obtained an acquaintance with the minute anatomy of the nervous system; and it became equally plain that this was an acquaintance which it would require no short time to form. I was therefore obliged to abandon the idea of writing on Epilepsy, and having begun at the beginning the present Essay is the result. Even yet I cannot flatter myself that I have adopted the maxim

"Semite materiam vestris qui scribitis aequam
Viribus"

But I think it only fair to myself to state that, in composing this thesis, I have laboured under considerable disadvantages. The Senatus Academicus permitted me to pass my examinations for the degree of M.D. last year; and now I am placed in a situation, where the want of a library is a serious bar to progress. It will perhaps diminish the surprise which may be felt at the small number of Author's whose works I have been able to consult, when I mention that, with one exception, every book I procured was through the rather expensive channel of purchase.

In the following pages the opinions of others have been freely canvassed. I trust I shall always be found to have borne in mind the high talents of those whose views I was discussing, and even when dissenting never to have spoken disrespectfully.

Gray's Hospital, Elgin
17 June 1864.

Conjectures have not been wanting as to the path which the fibres of the spinal cord pursue; their relation to the ganglionic cells; and the functions of both. Scarcely any other subject has given rise to such flat contradictions as to what are, and what are not facts; and to such endless differences of opinion as to how what are admitted facts ought to be interpretated. Anatomy, pathology, and experiments, have done a great deal to enable us to advance from the stage of hypothesis to that of theory; but while much has been learned, so much still remains unknown, so much of what

ought to be matter of fact, still remains matter of fancy, that no theory can be expected to be in every part not hypothetical. Considering, however, the very rapid progress which has been made of late years in this field of inquiry, there is no cause for despondency; but rather for believing that the night is far spent, and the day at hand. Several things contributed to prolong the darkness; and it brooded nowhere more thickly than over the mechanism of 'reflex' actions. They were commonly regarded as the results of anastomoses through the sympathetic. They induced some to imagine that the 'sentient principle' was diffused through the entire body; and others, not unnaturally, that it resided partly in the spinal cord. Whytt, after producing several instances of diastaltic actions, and proving that they cannot be accounted for by "any union or anastomosis of the nerves" themselves, concludes that "all sympathy must be referred to the brain itself and spinal marrow." The most convincing proof of the whole he conceives to be this, "that when any of the muscles of the legs of a frog are pricked, most of the muscles of the legs and thighs contract, even after cutting off its head, if the spinal marrow be left entire; but when that is destroyed, although the fibres of the stimulated muscle are

affected with a weak tremulous motion, yet the neighbouring muscles remain wholly at rest." "In many sympathetic motions, both in a sound and diseased state, we can plainly perceive a wise intention," but "these motions are to be referred to that sentient being which animates our whole frame, and which endeavours, at all times, to free the body from whatever occasions pain & uneasiness." Whytt therefore opposed the doctrine of nervous anastomosis, believed in the existence of motions which were involuntary, but did not believe in the existence of motions which were independent of the mind. Yet there were physiologists who long ago recognized a class of actions, excited by external impressions, which never became sensations. Of these physiologists Unger was one. He was aware, indeed, that sensory and motor fibrils were distinct from one another as such, and without regard to their peripheral distribution. "They are" he says "identical in structure, and only differ in their local relation. Each nerve may be either the one or the other according to its distribution: and each motor nerve is, at the same time, endowed with the properties of the sensitive." He thought, too, that an impression applied to the extremity of a sensory nerve could excite a 'sympathetic' or 'nerve-action' through its own ~~action~~ branches alone; and his ideas were very vague, also, as to where reflex-

on took place. The 'efferent impression' proceeded up towards the brain, and 'ere it reached there,' was the somewhat wide region in which it might turn back so as to operate like an 'internal impression'. He assigned to conceptional impressions a wider range of action, however, for he admitted that they might spread from nerve to nerve, through the medium of ganglia. Still, though without a clear understanding of how a reflex movement was effected, without indeed conceiving that the cord was implicated in its accomplishment at all, he had quite realized the fact that such movements did occur. He knew moreover that, in some instances, what was at one time a reflex might, at another, be a voluntary motion, and that both reflex and voluntary motions might exist together.

Prochaska distinctly perceived the influence of the spinal cord and of the ganglia in producing reflex actions; he pointed out how they might be excited without consciousness, or with it, or sometimes even against the will; and he observed, with Whytt, that their object was the preservation of the individual from injurious impressions, and the maintaining of him in such conditions as might be agreeable. Prochaska like the others believed the same 'nerve' – a most unsatisfactory and indefinite word – to be at once

sensory and motor — sensory, when an impression was applied to its peripheral, motor, when applied to its central extremity.

Haller would seem to have been acquainted with a class of movements due to the influence of the cord, in fact with reflex movements, for he distinguishes between movements due to the inherent irritability of muscle, and movements which take place after removal of the brain remarking that the latter may "continue to manifest themselves as long as the Spinal Cord and medulla oblongata remain uninjured." But that his notions must have been obscure is evident from the following statement of his own, quoted by Sir Charles Bell — "I know not a nerve which has sensation without producing motion also; the nerve which gives feeling to the finger is that which moves the muscles; and the fifth nerve of the brain branches to the papillae of the tongue." His opinions as to reflex actions were on the whole much the same as those of Whytt.

"With regard to researches into more remote antiquity, while the brain and its functions afford an extensive field for antiquarian zeal to explore, it is quite otherwise with the spinal cord, on which our more distant ancestors bestowed small attention, and which received from them a scanty literature. Considered until less

than thirty years ago as a mere appendage of the brain, or, if differently viewed by any, with no clear conception of its functions, and no conception whatever of its structure, it was rescued from its subsidiary position by M. Marshall Hall, who, whether his ideas be altogether correct or not, has at least the distinction of having been the first vividly to refer reflex actions to the cord — "the true spinal cord" — to point out distinctly a path which he considered the impressions producing those actions to traverse; in a word to originate the idea which opened up the way to subsequent discoveries. The merit of that discovery, without which those of M. Hall could have been impossible, belongs to Sir Charles Bell. It was he who first introduced order among the chaos, by demonstrating that sensory fibrilla are, from beginning to end, distinct from motor, and, of course, vice versa; and by stating, & partially proving, the theory, which Majendie succeeded in proving wholly true, that the posterior roots are sensory and the anterior motor. Plentiful objections were raised against the doctrine at the time, but now, although a quarter of a century at least has destroyed the bloom of novelty, it has grown perfectly secure. Perhaps we shall hereafter see that Bell's earlier opinions as to the track pursued by impressions from the posterior roots, through the cord, to the

brain, was so far correct, not altogether wrong, as Dr. Brown-Sequard would make them out, and as Dr. Charles himself confessed them to be.

I propose to describe the cord from a physiological point of view, because while entailing some repetitions it is the only method which enables one either to set in order the masses of facts, or bear them in memory, or embrace a sufficiently wide range in forming a judgment. To this end I shall describe 1 the mechanism for sensation; 2 that for voluntary motion; 3 that for the so called reflex, physical, or diastaltic motions. I am aware that in this arrangement it will not be possible to discuss any one subdivision entirely apart from the others, and particularly, that the last will be pretty fully treated of in the examination of the two preceding. The arrangement at all events will cause neither inconvenience nor obscurity, as I intend to have no scruple in breaking through it, whenever anything is to be gained by doing so. Of ~~Iteration~~ I shall carefully shun, and therefore premise a few remarks on the broader anatomy of the cord.

The Spinal cord is nearly bisected by the anterior and posterior median fissures, of which the former is perfectly evident, and forms a division between the anterior columns through out the entire length of the organ; the latter is visible only in the

cervical and lumbar regions, where there is narrower than the former, and in the back is quite indiscernible. Notwithstanding here, as elsewhere, the posterior columns are not united, but separated from each other by blood vessels and connective tissue, which penetrate as far as the central gray matter. The halves of the cord are linked together by means of two commissures,—the anterior of white, the posterior of gray; both the one and the other, however, being essentially composed of fibres, although in the one, they may be chiefly tubular, in the other, chiefly, if not entirely, caudate. Lockhart Clarke indeed denies the existence of a "proper transverse commissure" either of the anterior of the posterior columns. With regard to the anterior, there is a vastly preponderating mass of evidence on the other side, adduced by Kölliker, Todd, Van der Kolk, Brown Sequard, With regard to the posterior, viewed in the light of there being no direct communication, his statement may be true; but the argument he adduces in support of it, viz. that the posterior fissure extends down to the gray matter, I cannot see to be, in itself, any argument at all. May not fibres from the columns pass across through that matter to the opposite side? Would not his own discoveries show that they do so pass? Indeed I find no more telling witness against his views than himself; but to proceed further at present would involve repetition. Kölliker remarks that the anterior commissure is proportionate in size to the

the thickness of the motor roots. The posterior, as Clarke has shown, is broad (not larger however) where the corresponding cornua are small and conjoined; narrow, where they increase and become separate. Traversing the cord – & am borrowing Clarke's observation – and situate more or less near the posterior surface of the gray matter, according to the breadth of the commissure, is the spinal canal. It is continuous with the fourth ventricle, and is prolonged into the filum terminale; it is lined with ciliated epithelium, according to Kolliker, which Clarke only states to be cylindrical; and according to both, it receives support from a substance which is not nervous. This substance, the former, with Virchow, conceives to be the ependyma of the spinal canal, which, if it be of the same structure as that in the fourth ventricle [illegible], is composed of "a simple layer of epithelium," below which a layer of connective tissue is constantly developed. It appears to the latter to consist of an extremely fine circular band of fibrous tissue. Stilling, whom he quotes, believes the fibres surrounding the canal are gray – Goolle that they constitute the gray commissure of the cord.

Up, and near, the filum terminale, the posterior cornua having coalesced constitute the mass of gray matter, while the substantia gelatinosa crosses uninterruptedly from side to side. Ascending towards the lumbar bulb, the substantia gelatinosa divides, and the fibres of the posterior

commissure arch forwards, both narrowing that commissure, and marking off the posterior horns. These become speedingly broad in the middle of the bulb, and are there widely severed by the posterior columns. The cornua diminish in size from this point to the middle of the back, where the substantia gelatinosa again crosses as below the bulb. In their ascent from the loins the posterior bands of the transverse commissure are drawn, as it were, gradually backwards, becoming, at the same time, less curved, so that the space between them and the spinal canal is now correspondingly increased". Proceeding upwards the changes are reversed, and attain their consummation in the cervical bulb, where the posterior cornua are large once more, though not so large as in the lumbar bulb but are separated by a greater quantity of white matter. Still higher these cornua are ~~flanged~~ narrowed and encroached upon by a network of vessels below the substantia gelatinosa, and by bundles of fibres from the lateral columns. All these alterations in size & shape have been minutely described and figured by Clarke. Judging from the drawings of other authors his representations do not appear correct in so far as the cornua never coalesce, and the substantia gelatinosa is never undivided. Judging from what I have seen myself, I am very much disposed to think the S. gelatinosa extends right across; but I cannot conceive

why Clarke shows it in the form of a straight line; it certainly has a considerable fall towards the middle line. The Anterior cornua, also, undergo well marked changes in different regions of the cord. They enlarge and decrease along with the posterior but they never are conjoined; moreover they are shorter and thicker than the others, and are quite otherwise constructed. In the anterior, and in the roots of the posterior, caudate nerve cells abound; elsewhere in the latter, these vesicles are few, and in the S. gelatinosa cease to exist. Here the only cells to be met with are of a kind similar to those of the cerebral convolutions, that is to say, they are small, spherical, not caudate, and isolated. They are copious, too, throughout the rest of the posterior horns, and are numerously scattered among the caudate cells, and fibres of the anterior. Kölliker observes that many of them are no doubt nerve cells, but that many others are the cells of a common fibrinous plasma. With respect to the caudate cells, it is further to be observed, that "they increase in number in direct proportion to the size of the nerves with which they are associated;" (Clarke) and not only so but become most grouped together where the greatest quantities of nerve fibres are given off.

They are largest, as well as most plentifully, in the anterior horns, where, according to Van der Kolk, their chief

groups are placed. A very essential group, whose connections he has assigned with much precision, and which has received special notice from Clarke under the name of the "Posterior Visceular Columns", and from Kölliker, is situated in the radiation of the posterior commissure. There is another group in the middle of the gray matter, between the anterior and posterior cornua; and there is a fourth, at the base of the latter. Their numerical order coincides with the comparative importance attached to them by Van der Kolk; an author from whom, I take the opportunity of saying, I have received more aid in studying the minute anatomy of the cord than from any other. He believes, with Clarke, the groups to be arranged in columns which, however, are not independent of one another, but all more or less intimately connected. A fifth group is mentioned by W. Clarke as being situate at the outer border of the gray substance, between the anterior and posterior cornua, consisting of small, regularly shaped, caudate, cells; becoming distinct in the upper part of the lumbar enlargement; increasing in the dorsal region; diminishing in the cervical enlargement; increasing in the superior cervical region; where it "forms the principal part of the nucleus of the spinal accessory nerve."

The nerve tubes in the gray matter are very numerous, constituting, according to Kölliker, fully half its substance,

according to Van der Kolk, existing almost alone in the posterior comua; and according to Lockhart Clarke entirely alone (I mean of course with reference to other fibres) in the substantia gelatinosa. They are also very small — Kolliker stating that they have decreased by half from what was their size in entering the cord; Clarke that he has seen them 1/6000 of an inch in diameter, but that, even when so attenuated, they are perfectly distinct from the gray fibres, with which they have frequently been confounded. These are found along with the tubular fibres, but are scanty in the whole posterior comua, and in the S. gelatinosa vanish. A vertical section through those comua reveals a multitude of parallel white fibres, between which other white fibres run transversely (Van der Kolk) Clarke seems to take notice, as well as Van der Kolk, of the marginal band of fibres encircling the same comua, but not at all definitely, and the latter alone has assigned to them an important significance. In the anterior comua, besides the white, there are many gray fibres, processes of the caudate cells serving to connect them with each other. They ultimately break up into very fine transparent fibres, which form a most intricate mesh work, and some of which pass out into the anterior roots, possibly to be continued as the axis cylinders of some of the tubes. The fact of their passing out has not been recognized by Kolliker, who assumes they all

lie in the gray substance. Here no such arrangement of white fibres exists as in the posterior comma, that is, there are no parallel and longitudinal white fibres, but those only which pass into or through it.

When these fibres enter the cord they lose their neurilemma, become finer than in the nerves, and are more easily rendered varicose. So much indeed is this the case, that the varicosity has been looked on by some as their normal condition. They take different directions, ascending, descending, transverse, and they assist in forming the columns through which they pass. Three columns, I mention for the sake of completeness, are enumerated, — anterior, middle, and posterior, which are marked off by the fissures and the comma, but each of which merges in the other. Physiologically, the white matter may be viewed as consisting of an anterior (antero-lateral), a posterior (a postero-lateral column. It is impossible to coincide with Dr. Todd's assertion that the posterior columns are of uniform dimensions throughout nearly the entire length of the cord, and at the same time believe his own drawings correct. They agree almost completely with those of Arnold, as copied in Quain's Anatomy, which I have made some accurate measurements. I have chosen them in preference to Todds, because the parts are better defined and more easily wrought with. The measurements in

the posterior half of the cord proceed on the supposition that it constitutes a semi-circle, which is very nearly the exact truth. Let A. represent the posterior portion of the Cord in the Supra Cervical region: B. in the Cervical Bulb: C. in the Dorsal region. D. in the Lumbar Bulb.

A's diameter is 7¼ lines
B's 8½
C's 5½
D's 7½

Corona			Central Gray Matter			
Length.	Breadth.	Surface of both.		Length.	Breadth.	Surface
3	¾	2.25	A	3½	¾	1.31
4	¾	3	B	4½	1	2.125
2½	½	1.25	C	2¾	¾	1.03
2½	1¼	3.125	D	4	1	2.

Area of White substance minus the Corona

A = 39.55
B = 53.74
C = 23.75
D = 35.058.

Prop. of White to Central Gray matter. Proportion of White to both Cornua

3114	to 100	A	1754	to 100
2534	100	B	1791	100
2375	100	C	1900	100
1752	100	D	1121	100

Proportion of White to Central Gray matter + the Cornua

A 1111 to 100.
B 1048 to 100.
C 1041 to 100.
D 608 to 100.

Let the same letters represent the same parts in the Anterior portion of the cord.

Area of A = 11
B = 10½
C = 8
D = 9

Area of A's horns = 1½
B's = 1⅛
C's = 1½
D's = 3⅛

Prop. of White matter to horns in A. 633 to 100
B 460 100
C 433 100
D 200 100

Pollister's measurements agree on the whole; Clarke's plates, being all magnified twenty diameters linear, cannot be

~~The~~ compared with the others in details so minute as these. The views he gives, however, evidently corroborate as a whole those of Todd and Arnold. Otherwise indeed, than with regard to the amount of white matter in the superior cervical region, there is no difference of importance, physiologically speaking, between any of them. Kölliker would make out a larger quantity of white matter in the afores[illegible] region than in the cervical bulb, while according to all the others, this relation is exactly the opposite. Van der Kolk says that Arnold's plates show in the superior divisions of the spinal cord the posterior & postero-lateral columns to be much increased, but in this he is certainly mistaken if the plates are correctly copied into Quain's Anatomy. The white matter in those columns therefore appears most abundant in the cervical bulb, less in the superior cervical region, still less in the lumbar bulb and least in the dorsal region. The posterior comm is largest in lumbar bulb, smallest in the back, of considerable size in the cervical bulb and much smaller higher up. In proportion to its size the gray matter diminishes more in the back and upper part of the neck than the white cords; and the one is to the other greatest in the lumbar bulb, less in the cervical, least in the back and superior cervical region. The anterior and antero-lateral columns are not so large as the posterior; their size also is more uniform; but they nevertheless evidence

changes precisely similar to those which the others undergo. The horns, too, pay like those behind them but bear a much higher proportion to the white matter than the posterior do — a proportion however in both cases subject to like alterations. Consequently the remarks made with reference to the relative quantities of gray and white matter in the posterior half of the cord are equally applicable to that organ in its entirety. These are extremely important facts and have a powerful bearing upon the disputed question of how impressions are transmitted through the cord for which reason I have dwelt upon them somewhat at length.

From the entire surface of the cornua transverse fibres or rays, more numerous at the situations where the nerves emerge than in those intervening, and most numerous where the nerves are thickest, pass out into the white columns. Their nature has been much disputed, and is still 'sub judice'. It would seem certain that blood vessels from the pia mater & the cornua run along side the rays, but it seems equally certain that they are more than mere blood-vessels. Clarke conceives them to be processes from the cells, particularly from those near the margin of the gray matter, penetrating the white matter, by the fissures which contain the vessels. Todd thinks them processes of gray matter, of the same structure & colour as the central mass; while Van der Kolk's plates make them appear to be white tubular fibres. Pro-

bably the grayness may be owing to the vessels which are situated beside them. Their relation to the cells, to the nerve roots, and to the white columns, will be considered hereafter, in accordance with the plan I have already indicated.

The vessels of the cord pass into it from the Pia Mater. This membrane dips into the anterior & posterior fissures, by means of which, & the nerve roots, and of the rays, the vessels are conveyed to the gray substance; where, after having distributed branches to the white, and "without having become narrower to any considerable degree", they form a minute network. Kölliker says that, when they enter the cord, they are partly arranged in series. Two first at the bottom of the anterior fissure, one in the posterior, "and others not unfrequently correspond to the roots of the nerves, and the attachment of the ligamentum denticulatum." Clarke describes them, observing that round the margin of the comma they constitute a network of loops; that round the spinal canal also vessels from the bottom of the two fissures, and the posterior white columns, anastomose, while other branches pass out through the comma and join the peripheral loops. They are excessively like the nerve fibres and hard to be distinguished from them. Besides being strengthened by the vessels, the nervous elements of the cord, according to Kölliker, receive support from a quantity of connective tissue distributed throughout it, in which stroma

are the plasm cells which have been formerly adverted to.

It now only remains to say a few words concerning the roots of the nerves before proceeding to follow them into the cord. The posterior are thicker than the anterior — the sum of the transverse sections of the former, being more than double the sum of the transverse sections of the latter. While thicker however as a whole, their individual nerve tubes are fewer by nearly a half so that the number of fibres passing in behind is almost four times as great as the number entering in front. Though on pulling asunder the cord the posterior roots may adhere rather to the posterior portions of the lateral columns, than to the posterior columns themselves, it is wrong to say that they are therefore exclusively attached to the former. No one can follow them a step without perceiving that some fibres pierce the one, and others the other. As those roots are now admitted by every one to be purely sensiferous — not at all motor, and as the experiments which tell contrarily have been so fully explained away, there is no occasion for saying much more about them. I merely remark, therefore, that J. W. Arnold thought they were formed of fibres supplied to the skin alone. They were not, he believed, solely centripetal, but centrifugal also, serving at once to convey tactile and other impressions to the centres, and to produce those cutaneous movements which it is needless to observe are due to the action of muscles and the nerves supplying them.

As respects the anterior roots he held them to be distributed to muscles alone, and to suffice both for causing their contraction, and for informing the mind of their condition. Brown Sequard has a certain amount of faith in this doctrine because frogs can move nearly as well after, as before, all their posterior roots have been divided. But when it is borne in mind that, although so severe an operation has been performed and the path for impressions cut across, the mechanism for grouping together and harmonizing muscles in their actions has not been interfered with; that further most of the voluntary movements of which a frog is capable have been so frequently repeated that groups of nerve cells, if they do not exist 'ready made' at birth, must be formed in consequence of being many times combined, to combine in their turn the muscles necessary for effecting these movements; that the tendency of these groups is of course always to act together; that so, eventually, harmonized motions may be accomplished without any appreciation by the mind of the state of the muscles; when those facts are borne in mind the views of Arnold do not derive much support from the experiment mentioned. Indeed it is only by believing that there are different nerve fibres for different impressions (an hypothesis which I take to be very far from proven) that Brown Sequard can accompany Arnold so far as he does. For he has observed that no pain is caused

by the application of a galvanic current to muscles, the posterior roots of whose nerves have been divided. Consequently this sort of impressions travels through these roots, and not through the anterior. But the singular thing is that, after all, both sorts of impressions turn out to be the same; for a few pages before we find him saying that muscular contraction produces sensation by a "change in the galvanic state of the muscle". So Brown-Sequard asserts that a current from a battery gives rise to an impression which constantly passes by the posterior root, and that a current from a muscles gives rise to an impression which constantly passes by the anterior root. For my own part I know of nothing which can prove the existence of other than motor fibres in the anterior roots.

My farther task is to decide what the course is which the fibres of the nerve roots pursue, after having entered the cord. Beginning as proposed with the posterior roots — do the fibres which conduct those impressions that proceed to the brain, pass directly thither, or do they terminate in the gray matter of the cord? If they terminate in that substance do the impressions travel upwards in it, or do they emerge to travel by the posterior, and postero-lateral, Columns? Are the sensory and the motor fibres identical or different? These are questions which it is as necessary as difficult to answer.

There can be no doubt that part of the fibres of the posterior

roots pass into the posterior columns, with which indeed Clarke affirms that they are alone connected. Kolliker's observation, however, that they not only penetrate the posterior columns, but the region also where the posterior and postero-lateral columns are conjoined, seems to be the more correct. He thinks that the fibres proceed to the gray matter, both in an ascending and a horizontal direction, but he takes no notice of others which assume a descending course. Yet although they have been overlooked by him, as well as by Van der Kolk, who merely represents one portion of the root as bending beneath the pia mater to pursue a straight course upwards to the brain, and another portion as passing directly to the gray matter of the cord, such fibres unquestionably exist. They appear to have been first pointed out by W. Clarke, who remarks that the bundles which pierce the cornua may be traced into more roots above, below, and on the same plane with, themselves. The presence of descending fibres has been confirmed experimentally by Brown Sequard. He found that on dividing the anterior from the posterior part of the cord in a longitudinal direction, and on cutting through the posterior part thus isolated in a situation at the middle of, and in a line at right angles to, the longitudinal section, the lower portion still retained its sensibility, provided a few fibres of the roots and "some little parts of the posterior gray horns" remained attached. It would seem however that these fibres neither pass very far up nor down, before they enter the vesicular matter, for he represents a spinal cord divided in its

posterior columns at two heights, with five pairs of roots between the sections, and he states that the roots so placed sensibility persists, while it is lost to a pair with one section immediately above and another below them. How far the apparent pain produced by irritation of the caudal segment in this first experiment may be owing to reflex action I do not in the mean time stop to enquire; the phenomena which occur, whether voluntary or physical, prove at all events what Clarke says to be true, viz. that there are fibres which enter the gray matter at points lower than those at which they enter the column.

While traversing the columns the posterior radical fibres form a plexus which sends off those very minute fibres that radiate in the cornua. A drawing of Von der Kolk's displaying this plexus, displays also truncated nerve fibres which, lighter in colour than the rest of the columns, ascend between the transverse bundles. Apart from the question whether or not any fibres pass to the brain save those which originate from the cells of the cord, it is now generally admitted, as was indeed at the outset asserted by Stilling, that those ascending fibres enter the gray matter farther on in their course, an assertion which tallies with the views of Todd, Wagner and Volkmann, who hold that all the nerve fibres terminate in the spinal marrow. Von der Kolk, too, now agrees with Stilling, having recanted his first belief, and adopted the doctrine that the sensory fibres pass into the gray matter.

It is to be presumed of course that since he has come to regard the ascending as spiral fibres, he believes them also to enter the corona. When Kolliker likewise describes the whole of the fibres of the posterior roots as entering the corona, when Clarke's description is thus far to the same effect, except that he conceives from some fibres being lost to view in the posterior columns that they may ascend directly to the brain, and when physiology has rendered any other position untenable, it is impossible to deny credence to a fact so attested.

How the fibres comport themselves in that gray matter to which they have now been traced, has been, and still is, a bone of much contention among physiologists. I freely confess my utter inability, I do not say to throw the smallest light on the subject, but to perceive a good deal of what has been shed by others. In experimenting, my failure has been [illegible] more lamentable, and my want of success in making the sections, I desired, on the cords of men & brutes separated from their bodies, having been complete, I was not disposed to torture creatures without any prospect of obtaining an adequate result. It would afford me great satisfaction, and I would then believe in its possibility, could I see the cord so divided for instance, that while the posterior columns shall be left perfectly untouched, the posterior commissure shall be entirely cut through. On entering the gray matter

the ~~posterior~~ fibres of the posterior roots take different directions, some passing up, and others down, immediately in front of the substantia gelatinosa, some passing forwards between the longitudinal fibres. Although Kölliker seems to think that the longitudinal fibres remain longitudinal throughout, partly emerging into the posterior and lateral columns, partly passing back again into the cornua, Clarke's opinion that this "detect of tubercular matter" gives off fine bundles of fibres which proceed forwards, is much more probable. With these fibres are conjoined, from roots at various heights, other fibres which pass horizontally at once. Bundles of these, having penetrated almost as far as the bases of the anterior cornua, break up, and interlacing with each other, constitute a net work in whose meshes lie ganglionic cells, — those, namely, which form the posterior vesicular columns. Between the fibres and the cells Clarke has observed no union take place. But though of course not contemplating the existence of a cellular connection between the fibres of the anterior and posterior roots he affirms that the latter, proceeding in bundles, directly enter the former. Not was Stillings opinion, as quoted by him, much other, for he thought a connection between the roots was maintained without the intervention of cells, and solely through the medium of gray fibres. According to Clarke many of the fibres

from the posterior roots pass out also into the antero-lateral & anterior columns; some pass between the Spinal canal and the anterior median fissure – that is, I would say, they form part of the anterior commissure – into the same columns, on the other side; lastly, as what he has named "Antero-transverse fibres," some enter the gray commissure, and passing in large numbers behind the spinal canal, diverge on each side into the anterior and posterior gray masses, and extend into both the posterior and lateral white columns." Kölliker puts the facts succinctly, and says, that these fibres "are finally lost in the anterior horns, in the gray of posterior, and the anterior, commissure." They would pass, therefore, if Clarke's views were correct, into the anterior roots, and the antero-lateral columns (including the anterior) of the same side, and into only one of the columns on the opposite side. It is needless for me to point out how irreconcilable those opinions are, both with the paying side of the cord, and the results of experiments. So far as the conduction of sensitive impressions is concerned, I would borrow Brown-Sequard's remark that, were such statements correct, we would find on division of one half the cord partial sensory paralysis over the whole body, instead of what is actually found, complete sensory paralysis on the opposite side.

But the theory of Van der Kolk is by no means open to the same objections, and seems to me untouched by any argument Brown Sequard has advanced. The only part of it not well substantiated is his subdivision of the fibres into sensory and excitor sets — an hypothesis combated both by Todd and Wagner. Were the two distinct, we should certainly find the occurrence of sensation along with diastaltic action much less frequent. Seeing that according to himself both sets of fibres unite with cells, there ought to be special groups for either function; whereas the same group receives all the fibres; the difference in the mode of operation being, that, for the production of sensation, the stimulus passes from the cells it first affects to others on the opposite side, and thence to the brain; for the production of a diastaltic action, it passes from the same cells to a group on the same side, with which the motor fibres are connected. This arrangement evidently exists with a view to the preservation of the individual, for if the stimulus for such an action crossed over and caused the limb of the other side to move, it would serve no good purpose whatever. Although he fancies Brown Sequard's experiments require him to consider as sensory, those fibres which he previously considered excitor, it does not follow, unless the two sets had been first of all clearly proven distinct, that what he thought sensory must therefore

become efferent. Since they have not been proven distinct, this circumstance makes it more probable that they are identical, showing at least nothing in the state of the nerves themselves, to prevent the one set's performing the functions of the other, and of course despising of all weight the contrary statement which he urges as an objection against the opinion of Wagner. By Von der Kolk's own showing the ascending fibres must enter the cells before they can execute their reflex function, and while it is undoubtedly true that this function pertains to them, there is no reason why they should not be sensory as well as the more directly transverse which enter the same cells. Hence I think that one half of either proposition is correct, the other half incorrect; neither the ascending nor the transverse fibres are purely efferent nor purely ~~[illegible]~~ sensory, but each fibre in both divisions conveys (in one case) an impression! which may develope) a sensation, in another a reflex action. I leave this subject for the present as I shall have occasion to refer to it again when speaking of the mechanism for effecting the last named action. Meantime it may suffice to state that the object answered by the division of the root seems to be, the affording of a larger communication with the gray matter to a more limited part of the body than could otherwise be accomplished — a fact which, along with others, helps to explain the much more frequent persistence of sensibi-

lity than the power of voluntary motion, after extensive injuries to the cord.

The posterior fibres, having traversed and perhaps assisted to form, the marginal band which girds the posterior cornu, pierce the substantia gelatinosa, and arrive at the group of cells situated in the radiation of the gray commissure. In this group they are lost, and with it in all probability they unite; but their extraordinary minuteness has prevented Von der Kolk's being able to decide on this point with perfect certainty. These however are not the only fibres which disappear in this ganglionic group. The marginal band which is chiefly derived from the rays not only encompasses the cornu but also exists at its base, and thus enters the same group. It likewise transmits fibres to, and receives fibres from, the opposite side of the cord, and finally it is connected with those fibres already noticed which pursue a longitudinal course in the posterior cornua. Indeed that the sensory fibres pass, in their continuations, pass from one half of the cord to the other, has been affirmed by many anatomists and rendered certain by the investigations of Dr. Brown Sequard. He finds that on dividing the cervical enlargement bilaterally the sensibility of the anterior limbs is lost, forcibly because those fibres are cut through. He farther finds that the posterior limbs, which are

hyperæsthetic (?) after the operation, will, each of them, lose its sensibility on the opposite half of the cord being divided. It therefore follows that the impression which has arrived at those cells is, in its onward progress, transmitted across the cord; and as the fibres which convey it do not pass out of the gray matter, but unite with the corresponding group of cells on the other side, that becomes the next stage of the impression's journey. These cells Van der Kolk thinks are arranged in groups — he speaks principally, indeed, of the cells in the anterior cornua, but predicting of what persuasion he now is, with regard to the disposition of the sensory fibres, the same remarks apply to the cells presently under consideration — each of which groups, he conceives may be looked upon as typically connected with the brain by only a single fibre, and really by very many fewer fibres than those which enter the group.

The next link in the chain is formed by the rays which are composed of fibres emerging from the groups surrounding the cornua, piercing transversely the posterior and postero-lateral columns, and centrally bending up to run longitudinally in those columns and their continuations, until they reach the brain. An experiment, related by Brown Sequard, in which the whole cord save the anterior columns was divided, showed them also to be capable of conveying impressions, though very feebly, to

the brain; and showed, too, I may remark, by way of analogy, how probable it was that, when sensory fibres emerged from the gray matter in one situation, they should emerge from it in another as well. The conducts for impressions are therefore according to this theory, ultimately almost entirely the posterior and postero-lateral columns, and to an exceedingly small extent the anterior columns, and no doubt also that part of the lateral columns which is usually conjoined with them in function. This theory is not opposed to the fact that sensation may manifest itself although all the conductors have been cut across in any particular column, or some of them in every column. For to quote from B. Sequard "Every small portion of the conducting zone in a lateral half of the spinal cord, contains conductors of sensitive impressions from all the points of the body on the opposite side, which are behind the place of this small portion." Hence, when the posterior column is destroyed, the postero-lateral will convey impressions to the brain & vice versa: and when portions of both are destroyed, the remainder will, to a certain extent, perform the functions of the whole. But the theory is most decidedly opposed to the statement that, excluding the faint influence of the anterior white matter, sensibility remains, much less is increased, in the parts behind a section of both posterior and post-lateral columns. Further it ad-

nuts that sensibility vanishes from a part, should the corresponding part of the posterior fasciculi be destroyed, even if the white columns should continue intact. But destruction of the gray matter does not deprive the parts behind the injury of sensibility, while destruction of the white matter has that effect; seeing that, above the injury, there are fibres, from parts behind the injury, which have a communication with rays pursuing an uninterrupted course upwards to the brain. It is the only theory which is in harmony with the varying size of the cord in its different parts, at different heights; which is at all in keeping with the opinions of other anatomists; and which, while it is not overturned by his experiments, evades the difficulties of that advanced by Brown Sequard.

Of the many obstacles against which the experimenter has to contend the danger of mistaking between sensation and voluntary motion on the one hand, and motion from reflex action on the other, is not the least. For in brutes, the only signs of pain are the movements they make, and these, being directed to the same end as those which take place through the medium of the cord alone, - the withdrawal, namely, of the body from whatever is deleterious, - are identical with them. In the one case, the animal's safety is seen to by itself; in the other, it is provided for independently of the mind; but in the one case, and in the other, precisely the same means are employed to attain the same object. Who shall see the actions

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of a decapitated frog would suppose them to be performed otherwise than by the influence of volition; and who could distinguish what is voluntary from what is merely physical? It has been well observed, too, by Van der Kolk, that "if the brain be cut off above the pons Varolii, and the fifth pair of nerves be strongly stimulated, the animal will cry out, although without consciousness, without perception, and without the feeling of pain." Shrieking in fact, and the other vocal modifications which are commonly supposed to denote pain, are nothing more than reflex actions. It will be necessary therefore in order to upset the theory which has been advanced, to find instances of "articulate speaking men" who have had the posterior and postero-lateral columns of their cords destroyed, and yet have retained their sensibility, or who have lost the sensibility of all the parts behind the seat of an injury to the gray matter — the channel of communication through the white matter being uninterrupted.

The theory Brown Sequard proposes is this, that impressions, with the exception of those which enter the anterior white substance, ascend to the brain in the central gray substance. He endeavours to establish it by proving, in the first place, that they neither ascend in the posterior nor in the lateral columns, nor in both combined, nor in the same columns associated with the posterior cornua; and in the second place, by showing positively that they do ascend in the locality he mentions. The method he adopts is the following:— he divides the posterior columns and

finds hyperaesthesia (?) of the parts behind the section; he acts similarly on the lateral columns, and with a similar result. He divides all the cord save the posterior, and all the cord save the lateral columns, and in either case the result is the same, viz. loss of sensibility in the parts behind. He divides all the columns of the cord in the dorsal region, each section being at a different height from the others, and he finds that sensibility still remains. He divides the anterior half of the cord, and he divides the posterior half of the cord, and in both instances the so called sensibility is preserved. The most telling cases he brings forward in support of his view that the posterior white matter does not take up impressions, are two of Dr. Laboulbènes. One of them, and the other is like to it, is as follows — "A man, aged 24, after having had cramps, fornication and weakness in the lower limbs, and paralysis of the upper limbs, for a long period, was admitted at Charité. Sensibility existed everywhere. On the evening of the 1st November he was able to walk but aided by some one. Sensibility continued everywhere to the last moment before his death, on the 3. Novemb. at 3 A.M. Autopsy — Encephalon normal. There was induration of the spinal cord from its upper extremity to the third dorsal vertebra, and from the sixth dorsal vertebra to the lower extremity. The tissue of the cord in those parts being cut was hard looking like porcelain, hard and difficult to be crushed. The gray matter was also a little harder than normally, but of its usual colour. The anterior & posterior

roots seemed normal. In the space between the 3d & 6th dorsal vertebræ the cord was softened, pultaceous, resembling a whitish, or rather slightly rose, pulp, punctated in some places. When placed in water many parts became disintegrated, and formed a kind of emulsion. This alteration existed only in the white substance, the gray on the contrary seemed to have preserved its normal consistence. The microscope showed that the gray matter in both the softened, and the indurated, parts contained normal cells and fibres and normal blood-vessels; while the white substance, in the softened region, contained but rare fibres, which were altered, containing an oily matter and granulations. There was also a quantity of granulated corpuscles of inflammation, with many capillaries, oily drops and amorphous matter. In the indurated white substance there was less alteration, and the fibres were more normal and numerous" — Case 22. p. 82. Now we are told that sensibility existed everywhere, but since this was the case, when so large a portion of the cord was damaged, the sensory fibres passing into the gray matter cannot have been all destroyed, and this fact renders it unnecessary for us to believe that all the fibres passing out from it & the brain were destroyed either.

The rest of the evidence B. Séquard leads is competent to show that the posterior columns may be destroyed and sensibility continue, but it is not competent to

show that, when posterior and postero-lateral columns are destroyed together, then sensibility continues. We find one case intended to demonstrate, positively, that the gray matter is the channel by which stimuli reach the brain, although how it does so in the very least, I cannot perceive. It is short, and I will quote it. — "A gentleman suddenly lost all sensation and power of motion in the lower half of the body. Twenty-four hours afterwards there was a feeling of numbness in the hands, and imperfect power of using them. No reflex movements. Autopsy. Two small clots of blood amounting together to about a drachm were found in the interior of the medulla, occupying about an inch and a half in extent, and situated between the origins of the second and third pairs of dorsal nerves. The substance of the cord around the clots was somewhat soft; the medulla was more or less infiltrated and stained with blood from the site of the clots upwards, as high as the third cervical vertebra, and downwards as low as the last dorsal." — Case 27. p. 86. Phys. of Cent. nerv. syst. What does the case teach? Simply this, that extravasation of blood into the interior of the medulla deprives the parts behind of sensibility. If statements so vaguely made, can have any effect whatever, they disprove, rather than prove Brown-Sequard's theory. Nor do I think he makes it clear that hyperæsthesia exists in man after an injury to one of the columns — certainly there is no iota of proof that it exists after both have been destroyed.

Taking case X it as an example of the others we have a woman suffering from paraplegia along with acute pain in the lower limbs and abdomen; and the post mortem examination revealing a tumour two inches long & six lines wide, pressing against the left and posterior part of the cord, which was reduced in size at the seat of pressure, and, with the part below it, seemed softer than usual. But what of this? There is no mention of softening higher up, and the tumour irritated the healthy cephalic end of the compressed sensory fibres which convey impressions from the parts behind, and when subjected to a stimulus in the cord reflex (or caused the mind to refer, rather,) to those parts, the painful impression.

In examining in the light of clinical and anatomical facts the deductions which he draws from his experiments, they will, I believe, be found unwarranted. Possibly after dividing the posterior, or lateral, column, there may be hyperæsthesia although sensory fibres have been cut through, owing to the fibres which are left having been thrown into an irritable condition by the operation. But I am more inclined to think that the supposed hyperæsthesia is to be accounted for by the circumstance that, when the path to the brain has been broken up, the impression, not from being an elective agent, but because the cut fibre not having any means of discharging the current which enters it, shortly becomes charged to the utmost, passes to cells situate at the meeting of the anterior and

posterior cornua, travels upwards & downwards in them, and makes its exit by the motor roots, causing shrieking, agitation & the other phenomena which are regarded as denoting pain. The greater the number of emerging sensory fibres divided, the more will the reflex phenomena manifest themselves. Hence the mistake that when both posterior and lateral columns are cut through, hyperæsthesia is often more increased than when one only is divided, and hence why no shadow of a case can be made out by clinical & post-mortem observations on man. This explanation likewise applies to the experiment where all the columns of the cord were cut in the dorsal region, and the posterior limbs seemingly remained sensitive. Voluntary movements of course are stopped by the section of the descending fibres, but, as the injury to the directly motor fibres is purely local, reflex movements continue. When the anterior half of the cord is divided, there is no reason why sensibility should be diminished; when the posterior half is divided, the apparent effects of insensibility are the actual effects of diastaltic action. With reference to his dividing all the cord in one case save the lateral, and in another save the posterior columns, and finding that in either sensibility was lost, I have to remark, first of all, that the correctness of the statement is disputed; secondly that when a little gray matter is left undivided sensibility remains, and that it is an utter impossibility

for any human being to divide all the gray matter of the cord and leave any one of the columns intact; and thirdly, that when all the gray matter (of which there must be considerable destruction from extravasation of blood) all the anterior, all the lateral, and part of the posterior columns have been cut through, it is small wonder that irritation is changed for shock, and that sensibility should no longer appear. These, then, are the means by which Brown Sequard proposes to overthrow the theories of other people; let us see how his own theory stands the test of anatomical facts.

All agree that the gray matter is in a direct ratio to the quantity of volute matter passing into it from the nerves. Now were the theory we are examining true the gray matter should be found increasing as we ascend in the cord, disproportionately to the size of the nerves which enter, since it has not only to receive impressions from them, but to convey up impressions received at a lower point. It cannot be that impressions received in the inferior part of the cord ascend by those cells which receive impressions higher up, for thus inextricable confusion would be introduced by every impression's causing a sensation to be felt in the whole body above the situation of its entering the gray matter. Therefore gray matter must be provided for carrying onwards, as well as for receiving impressions, and this would make the proportion of that substance to the volute

much greater in the high, than in the low, regions of the cord. But what is actually the case? By referring to the measurements given in a former page we find exactly the reverse holding true; we find indeed the white matter decreasing considerably in quantity in the back, and again in the superior cervical region, but we find the gray matter in these regions decreasing to more than a proportionate extent. The decrease of white substance is evidently owing to the paucity of instant sensory fibres, - a circumstance which also explains the small quantity of vesicular matter, it being always directly proportionate to those; while the proportionate increase of white matter in the back, and in the upper part of the neck, is the consequence of the many additional ascending fibres from the cells of the lumbar & cervical bulbs. These remarks are equally true whether the comparison be held as instituted between the white and central gray matter, or between the former and the latter + the gray matter of the cornua. In fact the two are physiologically conjoined, and any attempt at a separation being quite artificial, can serve no good purpose.

It is proper to observe that in a diseased state cells seem capable of stimulating those both above and below them. But the result is the feeling of sensations in the parts to which the stimulated cells correspond. I have lately seen this circumstance illustrated by a case of ulcer of the stomach,

where painful sensations were felt over the whole left side of the chest and abdomen. They were stopped, acting on the suggestion of Dr. Todd by the application of ice along the spine. When the cells of the posterior vesicular columns thus operate sensations more or less extensive are the result; when the cells between the anterior & posterior cornua, more a less general cataclastic actions take place; when the cells of the anterior cornua the effects of volition cannot be limited to the performance of any particular movement. It cannot then be admitted that the gray matter is the medium for conducting impressions to the brain; it follows that that medium exists in the white matter, and it is plain that the parts of the white matter so employed are almost exclusively the posterior and postero-lateral columns.

The theory I have adopted shows well the analogy existing between the portion of the cord designed as the vehicle for impressions, and that as the vehicle for volition. The proportion of white matter to gray varies in the same manner in front as behind. In both cases we see in the back a very large increase of white matter over grey for the reason already given; in both the proportionate increase in the cervical bulb is not so great for the fresh ascending fibres from the back are few, the entering fibres are many and the gray matter is copious; in both there is another considerable increase in the superior cervical region, because there

are added
many new ascending fibres, and, because "the roots of the upper cervical nerves being smaller than those of the lower cervical nerves," (Quain) the quantity of gray substance in the former situation diminishes.

The anterior nerve roots pierce the cord in bundles without forming any interlacement in the white matter. After having penetrated a band of fibres which encircles the anterior horns they pass, according to Van der Kolk, into cells situated there. At their place of entrance several cells are to be seen sending off filaments into the roots; other fibres again can be traced to more remote cells; and others from the thinness of a section have their connection with cells cut off. Although the great decussation of volitional impressions does not take place in the cord, some fibres cross from side to side. From the group of cells into which the fibres pass, others emerge, which proceed to the opposite half, and in that situation gradually running along the side of the anterior fissure turn up into the anterior columns; partly entering the gray matter mingle with the fibres of the rays, and with them pass into the longitudinal columns. Brown Sequard says - "there is always (even in mammals, after a transverse section of the whole of a lateral half of the cord, at least some appearance of voluntary movements in the side of the injury, and always also a diminution of voluntary movements in the opposite side, so that in animals there seems to be,

in the spinal cord, a decussation of a few of the voluntary motor conductors." The decussation, anteriorly as well as posteriorly, occurs before the conductors of the impressions have commenced to travel longitudinally in the cord. In the one case the decussation requires to take place in the medulla oblongata, in the other where the sensory fibres enter the gray matter. Anteriorly as well as posteriorly, the rays form the medium of connection between the cells and the brain; and anteriorly as well as posteriorly, the cells are arranged in groups, each of which Van der Kolk thinks a single fibre might be able to charge with nervous force, although he does not think it probable that "nature would entrust so important an action to one single delicate filament." Yet while the number of filaments from the brain are not so few as to render the means of communication unsafe, they are few enough to account for the size of the anterior white matter, at its various heights. B. Legards experiments seem to show that the number of conductors in the different columns of the cord may disproportionately at various heights; but it cannot be easy to decide on so delicate a subject. Van der Kolk farther conceives that there are anatomically distinct groups of cells for each distinct movement, and that this circumstance explains the cause of its being impossible to act on some muscles unless when combined with others. He urges this hypothe-

sis as an objection against the opinion of Kolliker that the fibres pass directly from the brain, but so far as this individual matter only is concerned, the groups could with equal probability be conceived to exist in the brain as in the cord. And, even as it is, the mind must concentrate its influence on some particular brain cells, before it can impart a stimulus to the fibre which is to convey the impression to the group of cells in the cord. I cannot help doubting, however, whether there be anatomically distinct groups of cells at all, and I am disposed to agree with those who believe that any ultimate separation is the effect of an educational process, initiated by the frequent groupings which we are compelled to make in order that our motions may receive precision. Habit will give rise in the long run to artificial groups.

Kolliker conceives that the fibres of the motor roots, on having reached the gray matter, run chiefly in two directions. One set proceeds backwards and somewhat inwards, along the innermost part of the anterior cornu, there passes through a group of cells, but without forming any communication with them, arrives at the anterior commissure which it enters, crosses over, and finally ascends in the anterior column of the opposite side. Other fibres spread backwards in the direction of the posterior roots but are lost in the intricate network. The second set passes backwards and outwards through a group of cells into the an-

tero-lateral columns of the same side and ascend in it to the brain. Kolliker admits that fibres also exist which originate in the cells of the cord. Clarke states that on reaching the grey matter, the fibres break up into smaller bundles, and thereafter assume different directions. Some pass inwards partly to enter the anterior column of the same side, and partly to cross over and enter the opposite anterior column; some pass outwards partly to enter the antero-lateral column, and partly to cross over in the posterior commissure; some pass backwards, but these it is impossible to trace. As the objections to those opinions are very similar to what have been already advanced with regard to the posterior roots it is unnecessary to repeat them now. I may mention however that with the all important exception of their doctrines as to cell connections, the views of L. Clarke and Van der Kolk are not incapable of being reconciled, so far as the distribution of the radical fibres is concerned. The former for instance, says that fibres of the posterior roots cross directly in the transverse commissure; the latter that they first of all are united with cells; the former that other fibres pass directly to the anterior roots and to the anterior and lateral columns; the latter that fibres pass to cells which give off fibres that proceed to other cells, whence the motor nerves originate, and from which rays emerge into the columns Clarke has mentioned. I. P. C.

Simple view that credit arose owing to substi-
-tution of money — & that the common view [illegible]
genesis — & not explain how this is effected —

I have already stated what I believe to be the mechanism of diastaltic actions, and I have also stated reasons why there should be no difference between the impressional nerves which develope such actions, and those which develope sensations. The very fact of all the nerve fibres being inserted in the gray matter of the cord is a strong proof that the two sets are identical. Their being separate could be of no advantage as every diastaltic action is capable of being performed without any need of such an arrangement or fitting: and really in a case of this sort "Cui bono?" is an argument which may be used with propriety. Dr. Marshall Hall seems to have been upon his guard against asserting that there was any anatomical distinction, and to have confined himself to arguing for a physiological distinction between the sets. Now, although a sensation & a diastaltic are two different things, yet if they be produced through the medium of the same fibres, those fibres can scarcely on that account be said to be physiologically distinct, unless indeed the sorts of stimuli conveyed be different in the two cases. Therefore Dr. Hall considered that the stimuli were different; he considered that the stimulus which passed along the incident nerve, to excite a reflex action, was identical with that which passed along the excident, i.e. it was a motor stimulus which ran along a cer-

trifetal nerve fibre. But this hypothesis is not called for, it is opposed to all analogy, and it is totally unproven. Moreover it is an inconvenient hypothesis to hold, for the fibres must be conceived either to be or not to be the same. If they are the same then one fibre is both sensory & motor; if they are not the same then there is no occasion for any refining about anatomy & physiology and the preceding remarks become applicable. We have seen however that unless the stimuli be distinct we cannot admit the fibres to be physiologically distinct, without being anatomically distinct also. Hence those who believe in the one doctrine must likewise believe in the other. Dr. Carpenter and Mr. Newport have tried, but not successfully, to show that in insects the two sets of fibres are separate, and to argue from the circumstance that they are separate in man. It is sufficient to refer, without transcribing it, to Dr. Todd's refutation of their opinions. There are two other objections which he advances against the theory, namely the influence of emotion on paralysed limbs, and paralysis of the sphincter ani in certain cases of brain disease, where the influence of the cord on other muscles is not interfered with. For these reasons then I adhere to the view that the excito-motor nerves are identical with those which develope

a pulsation and respond to the stimulus of volition.

Such then is the power which the cord possesses over muscular contraction. But there resides in muscles a power of contracting altogether independent of the nervous system – a power which has been too much lost sight of in disease. I shall merely enunciate some propositions on this subject, without attempting to prove them correct, deferring this for an opportunity when I shall have more time to do so satisfactorily. They are as follow –

1. That muscle naturally tends to contract – witness the rigor mortis and various experiments of Dr. C. B. Radcliffe.

2. That it is prevented from passing into a state of contraction in the living body by the heat developed in the nutritive changes.

3. That, though the nervous system are furnished with a means of imparting a stimulus to muscle more potent for causing its contraction, than heat its expansion.

4 That the more rapid nutritive changes attendant on contraction produce the subsequent relaxation.

5. That defective nutrition, independently of the nervous system, is capable of causing muscular contraction, and that thus many of the phenomena of disease are to be explained.

6 That when the influence of the nervous system

is withdrawn, muscles pass into a state of contraction; that this is the consequence of defective nutrition and that thus many of the convulsions occurring in coma are to be explained.

7. That the more a muscle contracts, the greater is the expanding power developed, and that herein is an example of the vis medicatrix naturæ.

8 That treatment in such cases should consist of a copious supply of nutritive material, and a farther stimulus to the contracted muscles so as to endeavour to effect nutritive changes.

Henry Hall.