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(13.)

ON THE

PERIPHERAL NERVOUS SYSTEM.

By SAMUEL RHIND.

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The microscope reveals to us that the nerve fibres of the cerebro-spinal system are composed of two parts—a central grey portion, termed the axis cylinder, or grey band of Remark, and an outer sheath, called the white matter of Schwan, after its discoverer: these nervous elements are inclosed in a thin membranous investment, termed the neurilemma. There can be no doubt but that these two elements perform different functions. The central axis seems to be the true conducting portion; for, from Schwan's observations on the nerve fibres of the tail of the tadpole, plain fibres at first are only seen: these must perform their proper function of conduction: it is only at a subsequent period in their development that they seem to have added to them their investing white sheaths. Again, whilst the sheath appears to cease near a ganglionic cell, the grey axis is continued into it; this, also, is very significant: and, lastly, the sympathetic fibres seem exclusively formed of the central axis. I shall speak of the function of the sheath presently.

As these cerebro-spinal fibres approach their peripheral termination, they lose the double contour, and assume, for the most part, a perfectly plain appearance; either from losing entirely Schwan's matter, or from this becoming so extremely diminished as to be no longer visible. This peripheral condition is shown very well in the fibres of the retina; and here, according to Messrs. Todd and Bowman, the investing sheath is quite absent. It is also shewn well in the olfactory region, and in the fibres of the auditory nerve, distributed in the vestibule. Simple fibres have also been observed in the papillæ of the tongue. From Dr. Waller's very interesting observations, some of the fibres in certain of the papillæ of this organ end, as it were, with open mouths, as if the extremity of the central axis was only exposed. Wagner states that the fibres in the electric apparatus of the torpedo ultimately assume the plain condition. M. Quatrefages has shewn that the cutaneous fibres of the amphioxus divide into delicate homogeneous filaments.

In muscular tissue the ultimate fibres indicate much the same condition, and the fibres of the tooth-pulp have presented similar appearances. The very interesting observations of Professor Kölliker show that the fibres that pass into the cutaneous papillæ are plain, and without apparent structure. Now it is this plain, and, apparently, homogeneous portion of the cerebro spinal nerve-fibre, that I would regard as its *true periphery*—namely, that portion of centripetal fibres which, being in functional relation with a sentient surface, is capable of detecting the various stimuli, or that portion of centrifugal fibres which, being in functional relation with contractile tissue, communicates to it the motor impulse. I would therefore, for the sake of distinction, call the plain portion of the centripetal fibre the excitable portion; that in the centrifugal

the exciting. That this is the true interpretation will, I think, be evident, if we look a little more closely. If we take any of the above-mentioned examples, we find that wherever a fibre is to receive an impression, from whatever source, light vibrations, or from odoriferous or common irritating particles, or where a centrifugal fibre had to communicate a motor impulse, it presented this plain condition. But what does this condition of the fibre indicate? and why do we speak of this portion of it as specially its functional periphery in contradistinction to the rest of its course?

It has been before observed that the true conducting portion of the fibre certainly seems to be its central axis. By Schwan's observations, before alluded to, and from the case of the sympathetic, we may conclude, I think, also, that it is this portion which perceives the stimulus; so that, just as we should expect, whether the impression was at first received, then conducted, and at last conveyed into a ganglion cell, it would be by an uninterrupted extension of the grey central axis. With regard to the sheath, seeing that it is quite absent in one system of fibres—the sympathetic—and partially so in the cerebro-spinal, we cannot, I conceive, consider it as a conductor. The office that I would therefore assign to it is, that it is the economiser or allowancer out of the true functional periphery; for we find, as before stated, when the fibres come into any of the functional relationships just referred to, the sheath is either removed, as in the case of the retina, as if to allow the stimulus to exert its full strength on the exposed excitable grey axis, or else is so greatly diminished as, whilst it allows the impression to be made, yet modifies the intensity of the stimulus, just as (if we may take a rough example) a stimulus whilst it is allowed to pass. yet is modified in its intensity by the varying thickness of the cuticle over the papillæ. The probability, I think, is, that in almost every case the sheath is quite removed in this plain portion of the fibre.

When, however, the fibre is invested with its sheath in such quantity as to give it its double coutour, and when, in this condition, it passes into the trunk of a nerve, then it has commenced, we may believe, its true course in contradistinction to its true periphery—namely, that portion of its length which is solely for the conduction of an impression, and which is no longer capable of detecting through its thick sheath those delicate stimuli which I would term functional, to distinguish them from abnormal and violent ones. The importance of this will presently appear. Let us now proceed to see the bearing of this view upon certain physiological doctrines.

It is now a well-known fact, that a nerve fibre, if irritated unusually in its course, conveys to the mind an impression resulting from such stimulus which is referred by it to the peripheral distribution of such a fibre: to take a common instance, if the ulnar nerve is compressed behind the inner condyle, we have the sensation of pins and needles in the palm and back of the hand, the little finger, and ulnar half of the ring finger,—parts to which this nerve is distributed Some persons have assumed from this that the mind has no power of discriminating the very point of any nerve-fibre to which a stimulus has been applied. But Volkman has endeavoured to show that such an assumption is false; and that he is right, to a certain degree, all will admit, for in the case before referred to of the ulnar nerve, whilst the sensations were for the most part referred by the mind to its periphery, yet a dull pain also was felt in the seat of the injury. But when it is further stated that in the natural state of things the mind can discern the very point of a fibre irritated in any part of its course, there is good reason to doubt the truth of such an observation. Let us see the facts brought forward in support of it. It is said that if a needle be drawn across the back or thigh, or any part in which nerves are widely placed, the mind perceives the line of irritation as a straight one, and that if the impression was referred to the end of the fibres, sensations should be felt scattered about the line of irritation where the points of fibres crossed by the needle terminate.

Again, it is said, in the case of the retina, its whole surface is not so covered with the ends of nerve fibres that the images of any two points or lines must always fall on different fibres; but that if in any case they fall on different parts of the same fibre, and are seen as distinct, it must be that the mind can discern the points so irritated.

Now two things are assumed here:—first, that the usual part by which a fibre receives an impression is its extreme point, and secondly, that the parts so irritated form portions of the course of the fibre. With regard to the first, increasing microscopic observation shows that the looped arrangement obtains to a considerable degree in the nervous periphery. Professor Kölliker has proved it so for the skin, and I believe some recent research has proved it also to obtain in the retina; so that this idea must be considerably modified, and certainly is not tenable in the cases of those instances brought forward to support the doctines under consideration. As to the second point assumed, it has been my endeavour to show how both microscopic anatomy and physiology concur in evidencing that the parts of the fibres in question are truly their periphery, and not portions of their course. In the first of the two instances given, the needle, from being drawn merely along the surface, comes only into relation, or chiefly so, with the papillæ, and consequently with the plain fibres in them, and therefore with the true functional periphery. And when with this we consider the very interesting experiments of Weber on the sensibility of the back and thigh—namely, the parts in question, that two stimuli had to be thirty lines apart to be distinguished as distinct, we can at once, I think, see how the line of irritation would be a straight one, without at all supposing from such a fact that the mind could perceive a stimulus applied to a nerve fibre *in any part of its course*. Or, to refer to the instance of the fibres of the retina (and this is more satisfactory), the images of the points or lines would here fall on those portions of fibres which I have pointed out as their true periphery; consequently the mind could discern the exact points at which sixty or a hundred impressions might be made in the course of any one fibre: and I mention here a well-known fact, which I think is strongly confirmatory of the view before us,—namely that the optic nerve, ere it breaks up, is incapable of receiving the stimulus of a ray of light. Now up to this point the fibres are invested with their white sheaths: as soon, however, as they pass into the retina, then, the sheaths being deficient, they at once become irritable, and whilst, doubtless, this irritability is in a measure due to the presence of the vesicular nervous elements in the retina, as pointed out by Todd and Bowman; yet this fact speaks very significantly against the idea that a fibre can detect an *ordinary* impression in any part of its course.

Now the conclusions that have been forced upon physiologists from this confusion together of the periphery and course of fibres, are, that in health and under ordinary stimuli the mind can discern the exact point or points of a fibre stimulated as in the case of the retina; whilst under unusual stimuli, as in the instance of the ulnar nerve, the mind refers the irritation to the ends of the fibre If, however, the view I am bringing before you be the correct one, it will be seen that the first conclusion is unfounded, because the instances referred to are those of stimuli being applied to fibres in their true periphery; whilst with regard to the second, the fibres being there, unusually stimulated in their course, without believing any morbid condition of the fibres to exist, we recognize instances of that well-known law of nervous action before referred to.

The very fact itself of the mind referring an unusual stimulus made in the course of a fibre to its periphery, supports very strongly the present view; for if it was the custom of a nerve-fibre to detect an impression in any part of its course, the mind would be, by referring the impression to its periphery, always receiving false intelligence as to the whereabouts of any stimulus, and so confusion would ensue. It would be said by some, you allowed that in the compression of the ulnar nerve the mind could detect the seat of injury: how does this tally with your view? The question is easily answered. In the compression of the nerve unusual force is used, so that the white sheath is pressed on, and thus exercises in turn pressure on the irritable axis, and so a dull pain is felt, as we might expect; but this is far different from the gentle, healthy, and what I would term *functional stimuli*, applied to the nervous periphery,—such as the gentle vibrations that are accustomed to be detected by our senses

It is *only* for this functional relationship that I am contending. With regard to incised wounds, also, the sharp instrument severing the nerve fibres must

come in contact with the axis cylinder, and so the sharp pain is produced; for, as I have stated, the conducting part of a fibre and its periphery are continuous, and that it is the sheath which determines which portion of a fibre shall be its periphery, and which its course.

A word in passing with regard to the Pacinian corpuscules. It has been held by some that these organs are the result of disease. The nerve fibre, as it passes into one of these bodies, becomes plain; and we have every reason to believe it does so from either partially or entirely losing its sheath. If such is the case, I think, when the views expressed in this paper are considered, we must discard the idea above mentioned with regard to these bodies. If, indeed, there is this connection of nervous periphery with special structure, we must certainly conclude that they perform some office in the animal economy. One or two circumstances support this view. If a Pacinian corpuscule bends on it itself, then, at the angle of flexion, the double contour is seen, as if at this distorted part the functional relation of this organ and the nerve-fibre was destroyed. Again, a fibre, if it passes from one corpuscule into another, in the interval resumes its double contour.

We will now pass on to the last portion of my communication—namely, a consideration as to how far any of the views advanced in the previous portion of the paper elucidate or explain some of the phenomena observed in the sympathetic system: and let us also see how far they may aid us in investigating the functions, relatively considered, of the two great divisions of the nervous system—the cerebro spinal and sympathetic, or ganglionic. It has been supposed that the great cause of the difference of the phenomena observed in the latter system to those in the former depends on the number of ganglia that any one fibre has to pass through, and so that by ganglionic influence the conducted impression is diffused. Doubtless this is a principal cause of the difference; but it does not explain all; for it seems to me that physiologists by such reasoning seem to lose sight of the fact, that an impression made in the periphery of a spinal nerve-fibre, ere it reaches the sensorium, and is perceived there as a sensation, passes through the mass of ganglia that make up the spinal cord. Yet, in this case for the most part the impression is conveyed in all its integrity. Since, therefore, both impressions are subject to continued ganglionic influence; and since, also, those conveyed along sympathetic fibres seem always diffused, whilst those in the cerebro-spinal are only occasionally so, I think we must look for some additional cause to account for the difference of the phenomena observed.

Now this difference, that probably cannot be *alone* explained by referring it to ganglionic influence, receives, I think, some elucidation from a consideration of the previous communication. The white sheath has before been spoken of as the economizer or allowancer out of the true functional periphery of the cerebro-spinal fibres. Now since there is no such sheath in the sympathetic, there is, anatomically considered, an unlimited periphery; whilst, functionally regarded, we must limit this to that portion of those fibres in relation with a sentient surface or contractile tissue. Thus a centripetal sympathetic fibre may be capable of detecting impressions for a great length of its course; and thus, I think, might we explain with much probability some of the phenomena hitherto referred to the diffusion of impressions by ganglia. A consideration of this view may also help us much, I conceive, in understanding the reasons of the differences of contraction observed in the striated muscular fibres, and those of organic life. For whilst in the former a nerve-fibre may be in anatomical relation with the contractile tissue for a great part of its course, yet, from having its non-conducting sheath in considerable thickness, the impression cannot escape; but near its end the fibre either loses entirely, or in great part, its sheath, and there the impression escapes from its vital relationship with the muscular tissue, and in all its strength communicates to the few surrounding fibres the motor impulse, and so we have the sharp quick contraction. I have said that the sheath may not entirely cease; but we can easily understand how that though the fibre be in anatomical relationship with the muscular tissue, yet from the central axis being coated by a considerable quantity of its non-conducting sheath, the impression cannot at first escape, but when the sheath is reduced to its minimum, then, from the superior vital

attraction of the contractile tissue, it passes through its sheath, now unable to prevent its escape, as (and I only use it as an illustration) the electric fluid passes through a bad conductor to gain any body which has a superior attraction for it. If the fibre loses its sheath entirely, then, of course, no such explanation is needed. With regard to the sympathetic fibres the case is far different; for since they have no sheath, it follows that their functional relationship with the organic muscular tissue is exactly the same as their anatomical: consequently, the motor impulse is communicated to more of the contractile fibres, and through a greater portion of their length it is thus weakened; and thus can be explained the slow continued contraction of these fibres. In short, whilst the anatomical relation of the cerebro-spinal fibre bears no proportion to its functional relation with muscular tissue, in the sympathetic both are equal: of course the great influence that the difference of intimate structure of the two varieties of muscular tissues exercises in causing the two forms of contraction, is not forgotten in the above observations. The views expressed in this paper are quite consistent with that beautiful theory,—namely, that a nerve fibre has the inherent power of preventing the escape of an impression, till it comes into relation with that tissue with which it is functionally related. This is evident on a little reflection, so that I will not further comment on it.

If we hold this view,—namely, that nerve fibres have an inherent power of retaining impressions in their *true course*, we need not have recourse to the view hinted at by Messrs. Todd and Bowman, that the white sheath is an isolater of impressions, since the surrounding tissues would have no attraction for them, and so themselves would act as isolaters. Whilst we hold this as sound physiology, yet we must remember, however, that one fibre which we may suppose to be conducting an impression, is surrounded by many others capable of conducting in the same direction. I would therefore ask,—May not the sheath in the course of cerebro-spinal fibres have the office of preventing any communication between fibres themselves conducting in the same direction, and may not the absence of the same in the sympathetic allow of such communication? This question I ask cautiously, knowing that it rather clashes with received views; there are, indeed, some things which militate against it, yet, I think, after we have carefully considered everything, there is that which makes it sufficiently probable to warrant further attention. It will be at once evident that such a view would help us much in considering the relative functions of the two great divisions of the nervous system. I have in this paper endeavoured to point out that portion of a nerve fibre which should be regarded as its periphery, in distinction to its course. I do so cautiously, knowing that there are facts which might be urged against such a view. As far as I know, this has not been made the subject of special investigation before: enough, I conceive, has been said to warrant further inquiry; for it must occur to every reflecting mind, that we might expect to find a special peripheral arrangement in fibres for the detection and communications of impressions, just as we do a special central apparatus to receive, reflect, or transfer such.