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The conclusions expressed are drawn from investigations carried out in conjunction with

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It has long been recognised, by all who have interested themselves in the problems of sensation, that no view yet advanced of the structure and functions of the afferent nervous system is sufficient to explain obvious facts. The teaching of the anatomist throws little light on the difficulties with which the surgeon is confronted. On the other hand, it is difficult to reconcile the various views concerning the nature of common sensibility with the facts of clinical experience.

Such want of correspondence between observed facts and the prevailing general ideas showed that the distribution and function of the peripheral nerves required reconsideration. In the present paper we shall put forward a new view of the mechanism of sensation, based upon several different lines of research. If we may seem unduly to neglect the work of others, let it be remembered that

[1] The substance of this paper was delivered on May 23, 1905, before the Royal Medical and Chirurgical Society as the Marshall Hall address.

this paper is introductory to a series of communications, each of which will deal with one aspect of the subject more exhaustively than is possible in a preliminary statement of a new hypothesis.

When the median nerve is divided, sensation is entirely lost over a considerable part of both the index and middle fingers. Over the palm, within the area said by the anatomists to be supplied by this nerve, sensation is usually diminished and not completely abolished. In a similar manner, division of the ulnar nerve produces complete insensibility of the little finger, and of a variable portion of the ulnar aspect of the palm; but partial loss of sensation is found over a larger area of the palm and the ulnar half of the ring finger. Such is the usual statement of surgeons and anatomists. When they are asked, why sensation is only partially lost over the palm, the usual answer is, "Because there the nerves overlap." But if each nerve occupies the territory of the other to an extent sufficient to prevent absolute loss of sensation over so large a portion of the palm, it is obvious that destruction of the ulnar nerve must cause some diminution of sensibility over the median half. This loss should vary exactly in proportion to the amount of sensation that remains, after the median has been destroyed. But the most careful examination of the hand fails to show the slightest diminution in sensation over the median half of the palm in consequence of division of the ulnar nerve. What has always been called the diminished sensibility produced by the division of a nerve is really a condition in which some kinds of sensibility are lost and others retained. Within such a region of altered sensibility all sensation to light touch is abolished. If, in a patient who has divided his ulnar nerve, the ulnar half of the palm of the hand is stimulated with cotton-wool, no sensation will be produced, while the lightest touch will be appreciated directly the line corresponding to the axis of the index finger is transgressed. If the area is large enough to apply a pair of compasses, it will be found that the patient is totally unable to appreciate two points two centimetres apart. Not only is sensation abolished

to these tests, but careful examination shows that temperatures between 22° C. and 40° C. are not appreciated over this area. Thus, parts which have universally been considered to be areas of diminished sensibility turn out to be totally insensitive to certain higher forms of stimulation.

When the hand has settled down after the shock of the injury that has divided one or more of the nerves to the palm, it will be found that, although the area we have spoken of is totally insensitive to certain higher forms of stimulation, a stimulus producing pain, *e.g.*, a prick of a pin, causes a more unpleasant effect than over normal parts.

If the nerve has been united, sensation begins to return after a variable interval. The first sign of recovery is a gradual diminution in the extent of the area insensitive to pain and to all forms of heat and cold.

Finally, no part of the affected hand remains completely insensitive to all cutaneous stimuli. It is to the condition of a hand at this stage of recovery that we wish to draw particular attention. It might be supposed that, with the gradual disappearance of analgesia, an improvement would follow in the higher forms of sensibility. This is not so. The boundary at which light touch is lost is as definite as in the days following the injury, although sensibility to pain, to heat and to cold, has vastly improved. In this condition the hand may remain for many months, before light touch begins to be appreciated over parts that lie within the borders of altered sensibility.

Closer examination of parts in this condition shows that, although the hand has become sensitive to pain and to temperature, this sensibility is strangely altered. A prick is appreciated, but produces a sensation that radiates widely over the affected area. It causes unnatural discomfort, and the patient has an uncontrollable desire to withdraw his hand. Moreover, although ice and water at a temperature of 50° C. are appreciated as cold and hot, intermediate degrees produce no sensation of temperature, and water at 25° C. or 26° C. may be indistinguishable from water at 40° C.

We assured ourselves of the truth of these conclusions during more than two years spent in watching patients who had come to the London Hospital on account of injuries to one or more peripheral nerves. But it became obvious, that in order that we might examine more exhaustively the sensory condition of parts that had been robbed of their nerve supply, it was necessary that the patient should be a trained observer, and the injury determined beforehand.

On April 25, 1903, the radial (ramus cutaneus n. radialis) and external cutaneous nerves were divided in the neighbourhood of my elbow, and after small portions had been excised, the ends were united with silk sutures. Before this operation, the sensory condition of the arm and back of the hand had been minutely examined, and the distance at which two points of the compass could be discriminated had been everywhere measured.

This operation produced loss of all forms of cutaneous sensibility over an extensive area on the radial half of the forearm and back of the hand. Stimulation with cotton-wool, the prick of a pin, the application of all forms of heat and cold, were unappreciated, and the two points of the compasses could not be discriminated, even when separated to the furthest extent possible. But if this part was touched with the point of a pencil, the head of a pin or even with the ball of the finger, the stimulus was at once appreciated, and the point of application localised with remarkable accuracy. (Plate I., fig. 1.)

We are thus face to face with the conclusion, that complete destruction of all the sensory nerves to the skin leaves the part sensitive to most of those stimuli commonly used by the physician and surgeon as a test of sensibility to touch. With the Graham-Brown æsthesiometer, an instrument which measures the appreciation of irregularities in an otherwise smooth surface, the hand that had been robbed of all its cutaneous sensibility was found to be actually more sensitive than a similar part on the normal side.

Since all the nerves had been divided which supplied the skin, the maintenance of this sensibility must have been

PLATE I.

FIG. 1.

To show the loss of cutaneous sensibility produced by dividing the radial (ramus superficialis n. radialis) and external cutaneous nerves in the neighbourhood of the elbow. The thick line bounds the area insensitive to prick. The thinner line encloses the parts insensitive to cotton wool. Both the thick and the thin line are dotted wherever the borders of the area of loss of sensibility were not sharply defined.

The triangle marked A was insensitive to prick but sensitive to stimulation with cotton wool.

FIG. 2.

The area enclosed within the black line had become sensitive to prick, to water at 50° C. and to ice, but was insensitive to cotton wool, to water at 25° C. and to water at 38° C. The dots within this area are cold spots, the crosses mark the position of the hot spots. The two lines outside the affected area are divided into centimeters.

due to afferent fibres running with motor nerves. Sherrington (1) has demonstrated the existence of such sensory fibres and traced them to the muscles, tendons and joints. By the operation on my arm, we had gained the unique opportunity of exposing a part, endowed only with deep sensibility, to a series of careful tests.

The peculiar aptitude, possessed by a part innervated solely by the afferent fibres of a muscular nerve, is the appreciation of all stimuli which produce deformation of structure. Pressure or any jarring of the skin was quickly appreciated in my case, and, on the whole, was localised with remarkable accuracy. But, when the hairs were pulled, the elevation of the skin produced no effect upon consciousness. Pressure, which had previously caused a sensation, was no longer appreciated when applied to the skin lifted from the subcutaneous structures to form a ridge. This showed that the sensibility to pressure was not due to nerves still remaining in the skin after the operation. Although pressure was localised with considerable accuracy, all sense of form and size was lost over the parts affected. The prick of a pin and the interrupted current were entirely unappreciated ; but excess of pressure produced aching pain. When the pressure was produced by means of Cattell's algometer, it was found that pain was elicited with a smaller pressure of the instrument than on the sound side. The affected parts could be burnt without producing pain, and no sensation of cold was produced, even when the hand was frozen firmly by means of ethyl chloride.

This condition remained unaltered until seven weeks after the operation, when sensation of prick began to return on the arm. Six weeks later, there was no part of the forearm where prick could not be appreciated, and within 200 days from the time when the nerves were divided, even the back of the hand had become sensitive to this form of stimulation. Yet, for more than a year, both forearm and hand remained completely insensitive to light touch, and even now, more than two years after the operation, the hand has not completely regained its sensibility, when tested with cotton-wool and with the compasses.

Thus, we had ample opportunity of examining with care the sensory condition of a part sensitive to prick, but insensitive to light touch. We found that, when the forearm or hand was pricked, the pain produced was not localised, but radiated widely, and was not infrequently referred to some part at a distance from the point stimulated. Ice and water at 50° C. were appreciated, but minor degrees of temperature produced no effect upon consciousness. This peculiarity in the behaviour of the hand and forearm we found to be due to what are known as "cold" and "hot spots." (Plate I., fig. 2.)

Blix (2) first described the presence of "cold spots" in the skin, and his work was amplified by Goldscheider (3). To some observers, such as von Frey (4), all forms of sensation possessed by the skin are due to the existence of small areas of specific sensibility. So extreme a view has been accepted by few; some even doubt the very existence of temperature spots. By suitable methods spots can be demonstrated in the normal skin where cold alone can be appreciated; analogous spots, more sparsely scattered, can also be shown to be devoted entirely to sensations of heat. In the same way it would seem that there are spots peculiarly sensitive to the prick of a sharp needle; but the disturbance produced by their stimulation is so great, that they cannot be demonstrated with the same certainty as the spots devoted to sensations of temperature. Now *pari passu* with the return of sensibility to prick and to the extremes of heat and cold, these spots reappeared upon my arm and hand. But whereas, in the normal skin, the hot and cold spots are nothing more than minute areas peculiarly sensitive either to heat or to cold, set in a territory over which temperature stimuli can also be appreciated, the spots which made their reappearance on my arm during the first stage of recovery were set in an area insensitive to temperature stimulation. Thus, they were not only discoverable with unusual ease, but, since the only form of temperature sensation possessed by the recovering part was due to their presence, it was particularly easy to investigate their sensory peculiarities. The cold spots could be stimulated by any temperature

below about 24° C.; but, whenever a spot reacted, what might be called an explosion of cold was produced, not localised at the point touched, but radiating widely, sometimes even to a very considerable distance. A small group of spots on the wrist always produced a sensation of cold in the forearm just below the fold of the elbow, and two spots in the forearm, when stimulated, evoked a sensation of cold in the thumb. The hot spots, more sparsely scattered, behaved in a similar manner. The lower limit of temperature to which they reacted varied from 38° C. to 45° C. One extremely sensitive spot even reacted to 37° C. But, whether these spots reacted slowly or briskly, the sensation was always one of widespread heat, and, until the painful limit of heat was reached, it mattered little at what temperature the stimulus was applied, provided it lay within the limits capable of stimulating these spots. The following experiment, which demonstrates this peculiarity, was many times repeated with the same results. A cold spot of unusual activity was stimulated by means of a copper cylinder of one millimetre diameter, cooled to the temperature of melting ice. This produced a sensation of cold. Water at 20° C. was placed in a test tube with a flat bottom of one centimetre diameter, and this was applied to the skin in such a way that it stimulated a constellation of spots, among which lay the spot originally stimulated. The sensation of cold produced by this stimulus was more intense than that produced by stimulating a single spot with a temperature considerably lower. Thus we come to the remarkable conclusion that the hot and cold spots are incapable of producing, in consciousness, graduated sensations of heat or of cold. Water at 20° C. can be made to appear colder than ice, provided the stimulus is so arranged that the former is applied over a considerably larger area than the latter. Such spots resemble in their action the cold alarms of our greenhouses. When the temperature falls below a certain amount, a bell is rung, but no indication is given of the extent to which the temperature has fallen.

Although we had peculiar difficulty in demonstrating the

presence of similar spots for pain, the general behaviour of a part in this stage of recovering sensibility, closely resembles that of the hot and cold spots. Radiation takes place widely; a more intense stimulus is necessary to evoke pain, but when evoked, the pain is greater than over the normal skin. We also found that in this stage of recovery many of the hairs had gained a peculiar sensibility. When a hair on the normal skin is gently lifted, a sensation of touch is caused which is extremely well localised. But in the stage of recovery we are now discussing, the movement of the hairs produced a curious widespread formication, with the same reference to distant parts as in the case of temperature and pain.

However widespread the radiation may be to prick, to heat, to cold, or on touching the hairs, it is not fortuitous in its distribution. We found, by repeated experiment, that certain areas on the hand always caused radiation into some other part irrespective of the form of stimulation.

All these facts would seem to show that we are here face to face with an undiscovered form of sensibility, capable of producing qualitative changes in consciousness, but incapable of causing a quantitative change apart from the extent of area stimulated. The position of the point stimulated cannot be recognised and each stimulus causes a widespread, radiating sensation, not infrequently referred to parts at a distance. To this form of sensibility we propose to give the name "*protopathic.*"

The return of protopathic sensibility brings a cessation of all those destructive changes in nutrition that occur in parts where the skin is insensitive. Ulcers form, as the consequence of burns or cuts, and do not heal so readily as on the normal skin. But such trophic changes are confined to parts insensitive to protopathic stimuli. With the return of protopathic sensibility, ulcers cease to form, and sores heal as readily as on the normal skin, although the parts remain insensitive to all the higher forms of stimulation, such as light touch. Thus a part supplied by protopathic sensibility alone grows, and is repaired, as easily as the normal skin.

After the affected part has remained for a variable period

in this condition, it begins to become sensitive to light touch, and degrees of temperature, which produce the sensations called "warm" and "cool" on the normal skin, are again distinguished correctly from one another. With the gradual return of sensation, it again becomes possible to discriminate two points touching the skin at distances more nearly normal, and the widespread radiation, so characteristic of the first stage of recovery, ceases, and is replaced by an increasing accuracy of localisation. To this form of sensibility we propose to give the name "*epicritic*," since it is peculiarly associated with the localisation and discrimination of cutaneous stimuli.

So far we have demonstrated the existence in the skin of two forms of sensibility, but have brought forward no evidence to show that they depend upon anything more than modifications of the same system of nerve fibres and end organs.

I can now deal with a curious phenomenon that occurred in the case of my arm. Over the radial half of the dorsum of the wrist, a triangular area of skin became entirely insensitive to prick in consequence of the operation. But this same area remained sensitive to touches with cotton-wool, and also, in a limited degree, to warmth. The area was small, and its epicritic sensibility was of a low order, but in spite of these disadvantages, it became obvious, after repeated testing, that the area was capable of appreciating temperatures between 36° C. and 45° C. It was, however, entirely insensitive to temperatures of 50° C. and above. To ice and to all forms of cold, this part was equally insensitive. It would therefore seem that, by a fortunate chance in nerve distribution, we had divided those fibres which subserved protopathic sensibility, leaving untouched, at any rate, some of those which conducted the impulses of epicritic sensibility. Such an observation can only be explained by assuming that the two forms of sensibility depend upon two separate systems in the peripheral nerves. Experiments with so delicate a sensory change can only be carried out satisfactorily by frequent repetition, by selection of occasions when the patient is

from the sensory point of view, in excellent condition, and under the rigid check of a large number of controls. These conditions are rarely, if ever, satisfied during the examination of patients in whom the loss of sensation has been produced by accident. We have, however, seen this dissociation of sensibility in a patient where, during the removal of a small tumour from the nerves at the base of the brain, Sir Victor Horsley produced profound loss of sensation to prick over the one-half of the face, unaccompanied by an equivalent loss of sensibility to light touch. Here there could be no doubt that the patient could appreciate warmth, but not heat, and he many times stated that a temperature of 55° C. was neither hot nor cold, but that 43° C. was undoubtedly warm.

The mode of recovery of sensation after injury to a peripheral nerve also supports the view, that these two forms of sensibility depend upon separate structures. If the nerve has been completely divided, protopathic sensibility returns first, followed at a considerably later period by return of epicritic sensation. Provided the nerve has been completely divided, we have never seen the faintest sign of returning epicritic sensibility, unless sensation to prick had already shown material improvement. But, if the nerve is only bruised or injured, so that its continuity is functionally, but not structurally, destroyed, the two forms of sensibility may return *pari passu*.

Evidently, the two systems regenerate with unequal facility. The protopathic system regenerates more rapidly and with greater ease. It can triumph over want of apposition and the many disadvantages that are liable to follow traumatic division of a nerve.

Moreover, the length of the nerve to be regenerated makes relatively little difference to the time at which protopathic sensibility returns. Although the nerves in my arm were divided at a point at least 20 cm. above the wrist, recovery began in seven weeks and was completed, even over the hand, in twenty-nine weeks. This compares favourably with most of our instances of primary suture, in which the nerve was divided at the wrist. But this is in no way true of the

epicritic system. Provided the wound is healthy, and the operation of the primary suture has been successfully performed, the length of time required for epicritic regeneration depends upon the distance of the wound from the periphery. And this is why, in my case, the period between the close of the first stage and the beginning of the second stage of recovery was unusually prolonged.

Every peripheral nerve contains in varying proportion the fibres subserving these two forms of sensibility. Let us consider for a moment their distribution in the nerves, the trunks and the roots which supply the upper limb.

To simplify what must of necessity be a somewhat complex statement, I will deal first with the supply of epicritic sensibility only. On the palm of the hand, the area supplied by the ulnar and median nerves overlaps to an extent less than one-half the breadth of the finger. Consequently, the borders of the insensitive area produced by division of one or other of these nerves is well defined. The back of the hand can be roughly divided into two halves, by a line running from the knuckle of the middle finger to the middle of the back of the wrist. On the ulnar side of this line, the hand is supplied by the ulnar and internal cutaneous, on the radial side by a combination of external cutaneous, the radial and the long cutaneous branch of the musculo-spiral. If we now include the forearm, it will be found that a line drawn up the flexor surface continuous with the axis of the ring finger, and up the extensor surface, continuous with the line just mentioned on the back of the hand, divides the whole of the forearm and hand into a pre-axial and a post-axial portion. Of these the post-axial portion is supplied by the ulnar and internal cutaneous, the pre-axial portion by the median, the radial, the external cutaneous, and the long branch of the musculo-spiral.

Another border, which has the same character as these two axial lines, is the boundary separating the distribution of the median from that of the group of nerves supplying the radial half of the dorsal surface of the hand.

Whenever division of any nerve branch causes loss of sensation to light touch along one of these lines, that border

will be well defined. Division of one branch only will produce no definite area of anæsthesia, unless that area is bounded by one or more of these lines.

Thus, provided the peripheral nerves are gathered into certain groups, it may be said that from the point of view of light touch, and other forms of epicritic sensation, very little overlapping occurs. These groups are as follows: (1) The ulnar and internal cutaneous; (2) the median; (3) the remainder of the pre-axial group.

From this arrangement, the distribution of protopathic sensibility differs fundamentally. Enormous overlapping occurs, as we have already seen from a consideration of the analgesia caused by division of the median or of the ulnar nerves. Evidently, the peripheral nerves, looked at broadly, form the units of epicritic supply. On the contrary, from the protopathic point of view, no one nerve forms anything more than a tributary supply of an area innervated by a plexus of nerves, and, whenever a single peripheral nerve is destroyed in the upper limb, the loss of light touch always exceeds considerably the extent of the loss to prick. But, as soon as we have to deal with destruction of the cords of the brachial plexus, the extent of the analgesia almost equals that of the loss to light touch; and, when several posterior roots have been divided, the extent of the area insensitive to prick may actually exceed that insensitive to light touch. Thus it is evident that, whilst the unit of supply for epicritic sensibility, looked at broadly, lies in the peripheral nerves, the unit of protopathic supply lies in the posterior roots. The more nearly a peripheral nerve represents the supply of one or more posterior roots, the more definite will be the borders of the analgesia produced by dividing that nerve. The median nerve probably contains sensory fibres from the seventh and eighth cervical, and possibly even from the sixth cervical and first dorsal. Destruction of this nerve will therefore only cut off protopathic sensibility from the comparatively insignificant area to which all the fibres from these roots run in the one nerve. On the contrary, the distribution of the external popliteal, including its lateral cutaneous branch, corresponds closely to

that of the fifth lumbar root. Consequently, destruction of this nerve produces a widespread loss of sensation to prick, with an extremely well-defined border on the shin and dorsal surface of the foot.

The sensory mechanism in the peripheral nerves is thus found to consist of three systems :—

(I.) Deep sensibility, capable of answering to pressure and to the movement of parts, and even capable of producing pain under the influence of excessive pressure, or when the joint is injured. The fibres, subserving this form of sensation, run mainly with the motor nerves, and are not destroyed by division of all the sensory nerves to the skin.

(II.) Protopathic sensibility, capable of responding to painful cutaneous stimuli, and to the extremes of heat and cold. This is the great reflex system, producing a rapid widely diffused response, unaccompanied by any definite appreciation of the locality of the spot stimulated.

(III.) Epicritic sensibility, by which we gain the power of cutaneous localisation, of the discrimination of two points, and of the finer grades of temperature, called cool and warm.

Let us now pass to the consideration of the arrangement of sensation in the central nervous system. The view I shall put forward is based upon the examination of a series of cases of hæmorrhage into the spinal cord, and of injuries affecting its substance, producing what is usually known as Brown-Séquard paralysis. With these we have compared the sensory changes in syringomyelia and tabes dorsalis. Now, all these conditions demonstrate that, as soon as a sensory impulse reaches its first junction in the spinal cord, it becomes shunted into tracts devoted to the conduction of impulses, grouped in a way different from that found in the peripheral nerves. It is no longer a question of protopathic, epicritic, or deep sensibility; the tracts in the central nervous system are devoted to the conduction of impulses concerned with pain, heat, cold, and touch.

Thus, in Brown-Séquard paralysis, motion is lost in the one limb, and all sense of pain, heat or cold, is abolished in the other. Careful examination of this loss of sensation shows that sensibility is equally lost to all forms of tem-

perature stimulation, and that we have here to do with no such separation into extreme and intermediate degrees as exists in the peripheral nerves.

In the central nervous system, the impulses are co-ordinated and distributed, just as in the central office of a newspaper the various accounts of the same event, arriving by telephone, by tape, or by telegraph, are co-ordinated and distributed according to their subject-matter.

It has long been recognised, that the viscera are not endowed with the same sensibility as the skin, and some have even questioned whether they are sensitive at all. It is certain, from the observations of Lennander (5) and his school, that the patient shows no sign of pain when the gut is incised, or even when it is burnt; the liver is also apparently insensitive to similar injuries, and yet everyone is agreed that the parietal peritoneum is highly sensitive. We determined to attack the problem from a somewhat different point of view. When a colotomy has been performed, the upper end of the gut opens freely upon the surface, and no fæces pass into the lower portion. It is therefore possible to wash out the lower gut, and by passing a tube into its upper end to apply heat and cold to what is now an isolated loop of intestine. By choosing patients who were intelligent, and such as were not cachectic or wasted from malignant disease, we obtained the following result. Water at 40° C. and at 20° C., which seemed warm and cold respectively to the skin of the abdomen, were entirely unappreciated when applied within the walls of the gut. But ice water was at once called "cold," water at 50° C. was said to be uncomfortable, and two patients of unusual intelligence spoke of this stimulus as "hot." This sensation of heat and cold was never localised in the abdominal cavity. If the patient was asked to indicate the position of the stimulus, he either placed his hand over the region of the navel or pointed into the air. Sometimes the sensation was said to be like cold drops on the skin in a part of the abdomen where it would have been impossible for any water to have fallen. Moreover, the strictest precautions were taken to insert the tube through a ring of

mucous membrane and to surround both the tube and funnel with absorbent cotton-wool, so that no moisture could possibly escape.

These experiments are not conclusive, but they seem to show that, in some ways, the sensibility of the viscera closely resembles that which we have called protopathic. Only, the extremes of heat and cold are recognised, and localisation is so defective that the patient cannot even tell whether the cold is in or outside his abdomen.

Many of the afferent impulses from the viscera produce a reflex action without affecting consciousness. When we had passed a varying quantity of warm water into the gut, the patient complained that he wished to defæcate; a reflex peristalsis had been set up of which he was conscious, although he failed completely to recognise the stimulus by which it had been evoked. Most of the afferent impulses from the stomach and intestines probably belong to this order.

To a certain extent, we seem able to appreciate the muscular movements of an internal organ, such as the stomach or intestine, even although we cannot recognise the position in space of the part that is moved. This power is probably the equivalent of that deep sensibility which remains to a part deprived of all its cutaneous sensory nerves.

Structurally, we know that the viscera are innervated from the sympathetic system, and from a set of large afferent fibres connected with the end-organs of Pacini. The latter so closely resemble the mechanism found in muscles, tendons and joints, subserving what we have called deep sensibility, that we can assume the end-organs of Pacini to be the means by which we gain a similar power of appreciating intestinal movement.

But apart from such sensations of movement, the viscera certainly set up afferent impulses which may affect consciousness. We have attempted to show that, however feeble these sensations may be in consequence of the defective innervation of the intestine, they produce upon consciousness an effect resembling that of a low form of protopathic sensibility. Now, one of the peculiarities of protopathic

sensibility is the rapid restoration of the mechanism upon which it is based. This it shares with the sympathetic system. Moreover, when a peripheral nerve to the hand is divided, it is noticeable that the palm begins again to sweat at a time after union which coincides approximately with that of the return of protopathic sensibility. This sweating is due to the motor fibres of the sympathetic (the "autonomic fibres" of Langley) that supply the skin.

It will therefore be no adventurous guess to suppose that the system we have called protopathic in the skin is one with the afferent fibres of the sympathetic as they supply the viscera. In both cases the sensation is badly localised, radiates widely, and is frequently referred to parts other than those stimulated. Both systems are incapable of appreciating light touch, and both are insensitive to the minor degrees of heat and cold. Both regenerate with the same rapidity and completeness.

We wish, therefore, to put forward a new conception of the nature of the afferent fibres in peripheral nerves.

The whole body within and without is supplied by the protopathic system. The fibres of this system in the skin may be spoken of as somatic, those to the internal organs as visceral protopathic fibres. Thus we shall no longer speak of the afferent sympathetic system, but of the protopathic supply of the internal organs.

Another set of afferent fibres peculiarly associated with impulses of movement and pressure exist in connection with the Pacinian organs. In the body and limbs, an analogous system is found peculiarly susceptible to pressure, to the localisation of movement, and to the appreciation of position. The fibres of this system run in conjunction with the motor nerves.

In addition to these two systems, which are distributed to all parts of the body within and without, the surface of the body only is supplied by a third system, which we have called epicritic. This endows the skin with sensibility to light touch. To the impulses conducted by this system we owe the power of localising the position of cutaneous stimuli, of discerning the doubleness of two points, and of

discriminating between minor degrees of heat and cold, and other special attributes of sensation. The fibres of this system are more easily injured, and regenerate more slowly, than those of the protopathic system. They are evidently more highly developed, and approach more nearly, to the motor fibres that supply voluntary muscle, in the time required for their regeneration.

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