ON

A NEW THEORY OF NERVOUS ACTION

AS REGARDS THE TRANSMISSION OF SENSATION ALONG THE NERVES.

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[Abstract.]

[Read before the Royal Irish Academy, May 23, 1870.]

A LARGE number of facts have of late years been observed, tending to show that what has hitherto been regarded as the sense of touch is capable of being resolved into a number of comparatively elementary sensations, as those of temperature, contact, tickling, pain, &c.

Many cases have likewise been observed in which some of these sensations are felt, while others cease to be perceived by the patient. Thus the individual may feel perfectly the contact of the hand, when lightly rubbed over the surface, yet not be able to distinguish heat from cold, or *vice versâ*.

Analogous phenomena are observed with regard to the other senses, as in cases of colour blindness, absence of ear, or inability to hear particular notes, &c.

In explanation of these and other kindred phenomena, it has been supposed that there exist in every nerve groups of distinct conductors, each adapted to convey along it distinct nervous impressions.

This hypothesis is indeed that which is at the present time adopted by physiologists, and it numbers among its supporters the most distinguished philosophers.

Dr. Brown-Sequard conceives "that he has ascertained that, beside the four distinct kinds of nerve fibres of the higher senses, there are at least eleven kinds of nerve fibres in the spinal cord, and in the cranial, spinal, and sympathetic nerves."

He enumerates these eleven kinds as follows :—

1st. Conductors of impressions of touch.
2nd. ,, ,, of tickling.
3rd. ,, ,, of pain.
4th. ,, ,, of temperature.
5th. ,, ,, of muscular contraction.
6th. Incito-motor conductors.
7th. Incito-nutritive and secretory conductors.
8th. Voluntary motor conductors.
9th. Involuntary motor conductors.
10th. Vaso-motor conductors.
11th. Nutritive and secretory conductors.

"I hardly need say," he adds, "that the number of functionally distinct nerve fibres is probably much greater than is shown in this table."

As regards the physiology of sensations of colour, a theory so closely analogous as indeed to be identical with reference to the sense of vision was put forward by Thomas Young, at the commencement of this century. He supposed three sorts of conductors to exist in the optic nerve, each specially charged with the function of conducting a different colour, red, green, and violet. The mixture of these three colours in different proportions gave rise to all the other colours of the spectrum.

This hypothesis of Young has, with some modifications as to the colours, found a zealous advocate in the distinguished Professor Helmholtz.

It is not necessary for my purpose to enumerate the various theories which have been advanced in explanation of the various phenomena to which I have just alluded. Suffice it to say that I have long felt that the ingenious idea of distinct conductors did not exactly meet the case. So long ago as in 1861, in a critique on Dr. Brown-Sequard's work in which his theory was first put forward, I expressed the opinion that we could hardly accept the idea "that the nerve fibres employed in the transmission of sensitive impressions of *touch*, *tickling*, *pain*, &c., are as distinct one from the other as they all are, from the nerve fibres employed in the transmissions of the orders of the will to the muscles."

The theory which I venture to propose, and which I put forward with diffidence when I consider that another has been advocated by such able physiologists as Helmholtz and Brown-Sequard, is simply an application of the theory of wave propagation to the passage of various sensations along nerve conductors.

I conceive that the various peripheral expansions of sensitive nerves take up undulations or vibrations, and convert them into waves capable of being propagated along nervous tissue (neuricity, as it has been named). Thus, the same nerve tubule may be able to transmit along it vibrations differing in character, and hence, giving rise to different sensations ; and, consequently, the same nerve tubule may, in its normal condition, transmit the wave which produces the idea of simple contact, or that which produces the idea of heat—or, again, the same nerve tubules in the optic nerve which propagate the undulations of red may also propagate, in normal vision, those which excite the idea of yellow or blue, and so for other senses.

I advocate this undulatory theory of sensation in preference to the theory of distinct conductors—

1stly. Because it is simple.

2ndly. Because it is strongly supported by analogy, when compared with wave propagations in other departments of science.

3rdly. Because it appears to be in harmony with a large number of recognized physiological facts, which seem inexplicable upon the theory of distinct conductors.

It would be obviously impossible, within the limits of one communication, to discuss such a theory in its application to the various senses. I wish merely to bring before the Academy, at present, a general statement of the grounds upon which this hypothesis rests; and I shall hope, hereafter, in several communications, to elucidate its applicability to the transmission of the sensations peculiar to each special sense.

1st. When compared with the theory of distinct conductors, the undulatory theory is obviously simpler as regards anatomical detail. Anatomy has not given any evidence that with an ordinary compound nerve there exist different kinds of conductors—to the highest powers of the microscope all such tubules are identical in appearance. Nay more, we now know that nerves may be so spliced (if I may use the expression) on to one another, that sensitive nerves may be made continuous with those which convey the commands of the will to muscles.

As regards the analogy between this theory of nerve action and the wave theory of light, I do not pretend to say that it holds in every respect: there are obvious points of difference. If we infer that light and heat do not consist of particles emitted by a hot body, our natural alternative is to suppose that they are undulations of a medium pervading space. This hypothesis furnishes by far the best explanation of many very curious phenomena in light and heat, and is now generally received. This medium, which we suppose to pervade space likewise, with more or less freedom, pervades transparent and diathermanous bodies; but nerve tissue being neither transparent nor diathermanous, it is not to be conceived that the undulations of this medium are transmitted along nerve tissue, as if through glass or rock salt: on the contrary, the vibrations of light and heat are transferred from the medium in question to the axis cylinder of the nerve tubule in a form capable of being propagated to the sensorium.

As I conceive, the analogy lies chiefly in this:—as we know, various solid and liquid bodies exercise a selective absorption both for heat and light, in virtue of which certain rays are set apart to be stopped, while certain others are allowed to proceed; after an analogous fashion, certain nerves exercise a so-called selective power, permitting certain undulations to proceed, while those of a different wave length are intercepted. Most substances, including those that are transparent for light, are generally opaque for dark heat of great wave length and small refrangibility. So we have no reason to think that heat can excite in the retina undulations capable of being propagated by the optic nerve to the sensorium, although light certainly does so.

Instead of supposing, like Dr. Brown-Sequard, that there exist a great number of distinct conductors, I should suppose that there are a great number of distinct sensations propagated along the nerve tubules, in undulations of different wave lengths.

As the rays of the heat, light, and actinic spectra differ in refrangibility, so do the undulations produced by heat, cold, pain, tickling, or the unfelt sensations (if I may use the phrase),—which last correspond to the invisible and cold actinic rays.

As in the economy of nature the actinic rays play a part of vast importance, so these vibrations, which play along our nerves, without our knowing it, are all important in the animal economy.

The unfelt tickling, which keeps the heart in regular and ceaseless action during life, is not less important to man than that part of the sunbeam which we cannot see, nor yet feel the warmth of, is in the economy of nature.

Many phenomena such as those connected with seeing complementary colours, when a white surface is gazed at, after the eyes have been fixed upon a blue, red, or yellow disc; the phenomena, connected with peculiar colour, seen after the administration of santonine; the effects of lead poisoning upon sensation, &c., &c., are more easily explicable upon the undulatory than upon any other hypothesis of sensation.

The author concluded by referring to the well-known experiments of Professor Tyndall, showing the power of absorption of vapours and scents, of which minute quantities are introduced into dry air filling a glass tube. In these experiments a physical change of almost inconceivable subtlety is followed by the interception of waves of radiant heat. So with a nerve tubule—a minute quantity, suppose, of santonine, entering into the axis cylinder of the optic nerve tubules (as the scent in the air filling the glass tube), intercepts some light waves of a certain refrangibility; and the result is, that all objects looked upon have their natural colour, *minus* the intercepted undulations. This analogy serves to explain the general bearing of this hypothesis.

THE END.