THE NEUR-ELECTRO-MAGNETIC THEORY OF NERVE REACTIONS, INCLUDING THINKING

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Since the end of the nineteenth century (1874) it was known that electrical currents can be deducted from the forebrain of lower animals such as rabbits, cats, dogs and monkeys, and that these electrical currents undergo oscillations. Investigators, working independently on the same problem and arriving at the same or similar conclusions, have brought to light these undisputable facts. But not until the beginning of the twentieth century were those researches extended to the human brain, especially by Prof. Hans Berger of the University of Jena who detected the same delicate electrical currents and the same marked oscillations in the brain of man, demonstrating them beyond a shadow of a doubt. In his footsteps have followed others, L. V. Heilbrunn, R. Fuerth, R. Beutner, Wilhelm Ostwald, K. S. Lashley, L. Lapicque and A. Rizzolo, and a member of our own illustrious academy, Dr. M. O. Wilson whose fine paper on chronaxic switching was read last year. Recently the late Dr. R. A. Spaeth of Johns Hopkins University, also Dr. Edmund Jacobson of the University of Chicago, have been carrying on research work along similar lines, the former experimenting with iron wires dipped in acids, the wires resembling in their behavior nerve conductors, very strikingly indeed; the latter detecting by means of very delicate galvanometers extremely fine electrical currents in a muscle even before its contraction, the currents being started through the mere thinking process of the person experimented with upon a given signal.

Although our activities are now restricted to other scientific fields, we are more or less familiar with batteries and power stations, with telephone and telegraph wires, with radio; we perhaps know something about he theory which attempts to explain the conveyance of electrical "impulse" from the positive to the negative pole; we are familiar with insulation, with how to measure the velocity of a current and express it in units; how to increase or decrease this velocity; how to measure the strength of a current and how to increase or decrease this power. We see an electrical spark "jump" the gap between two electrodes, the cathode and the anode. And, on the other hand, in our capacity as biologists, and more especially physiologists, we are familiar with the delicate structure of the nervous system; the different units in a nervour arc; its afferent and its efferent nerve fibres, its association fibres and their synapses. And we trace with equal facility the course a given stimulus which irritates a certain sense receptor, must take in order to reach the spinal cord and its ganglia or proceed higher up into the brain. We can tell with equal ease which course a nerve "impulse" going out from the brain or from the spinal cord must take in order to convey a certain message to a muscle which, through its contraction, moves a certain limb or other part of the body. We can, with dead certainty, foretell how a normal organism must behave under given circumstances, and upon a given stimulus. We perhaps know also from experience that such reactions can be accelerated or retarded at will. We know that such nerve reactions can be made stronger or weaker by application of certain stimuli. Or that they are "per se" weak in one individual and strong in another.

Why not then make an attempt to explain what really happens in the human nervous system in terms of electro-magnetism? Parallels have been drawn, to be sure, between a coordinated telephone or telegraph system with its batteries and power stations, its insulated conducting wires and cables and sidelines, its shunts, its accumulators and its sparkbreaks,

on the one hand, and a coordinated nervous system with all its neuron units, end units and central units, its ganglion cells, multipolar, pyramidal and spider cells in the cortex of the brain; with its collaterals and its synapses, with its various sense receptors for the reception of the different kinds of stimuli; with its local sense areas, highly specialized ultimate receiving stations, as we may call them; with its equally highly specialized motor areas where the "impulse" is created that reacts upon a given stimulus, either at once or after some deliberation; with the peculiar way in which certain afferent nerves at first wind around a sense bud several times before they finally enter the latter, leaving their medullated sheaths behind. But so far as this author is aware no one has ever gone beyond this analogy, this parallelism.

But, so we ask, why stop here at the very threshold of the mysterious workings of the human nervous system? Why not dare go one step forward and boldly declare: All nerve reactions, involuntary and voluntary, are in the last analysis but manifestations of that same PAN-ELECTRO-MAGNETIC force which pervades the multi-universe, as this author prefers to call it? Why not boldly say: What we in ordinary physics call electricity and magnetism are nothing but especial phases of this pan-electro-magnetic force in which elements ultimately find their expression, to which ultimately all elements, their physical and chemical properties, all their physical and chemical reactions can be reduced? Why not, by one grand "coup-d'-etat," so to speak, bring all happenings in this multi-universe under one head, and make them all revolve about one common hub of pan-electro-magnetic force, even the delicate reactions of the brain and the rest of the nervous system?

What hinders us? The fact that electrical currents exist and oscillate in the nervous system, in the brain, has been demonstrated beyond a shadow of a doubt by brilliant investigators. Why not admit, therefore, that medullated nerve fibres may not only be compared to insulated telephone and telegraph wires and cables but that they in fact ARE SUCH INSULATED WIRES AND CABLES, worked out in the work and research shop of nature before man ever thought of inventing the telegraph and telephone? Why not admit that those ganglion cells and multi-polar cells and pyramidal cells in the cortex of the brain and in other parts of the nervous system may not only be compared to but that they in fact ARE ELECTRICAL BATTERIES AND POWER STATIONS where neur-electro-magnetic energy is stored up and is as such available? Why not use our imagination a little? Any theory, any hypothesis, calls for a certain amount of imagination.

It is for all these various reasons that I propose to interpret all nerve reactions in terms of electro-magnetism. And because the kind that makes itself manifest in our nervous system, including the brain, is by nature somewhat different from what we in ordinary physics understand by electricity and magnetism, I propose to introduce the new term: Neur-Electro-Magnetism.

Taking for granted now that all matter radiates and in so doing vibrates at a certain fixed rate of frequency, the author of the theory assumes that also stimuli which come to us from the outside, arrive as radiations of a certain vibration-frequency, each stimulus, for instance that of a certain type of musical sound, having its own vibration-frequency of radiation. The author further proposes to express each vibration-frequency of radiation in form of a PATTERN, each stimulus having its own, particular and characteristic pattern. In order to aid our imagination, we may call to our assistance such other patterns which we are more or less familiar with, for instance the so-called sound figures,

"klangfiguren" of Cladni, or the interference figures of polarized light, or the graphic expressions of very complicated chemical formulae.

Let us now suppose that such a vibration-frequency pattern of radiation hits a certain sense receptor. Of course it hits all sense receptors of a certain organism. BUT it will stimulate only that one which has been built up in the course of evolutionary adjustment as that particular sense receptor which will respond to this particular vibration-frequency pattern, to this particular stimulus.

Being reassured of the validity of the electronic theory of the conveyance of an electrical "impulse," the author holds that the impact with which the pattern hits this particular sense receptor, "knocks off," so to speak, one electron from the first of a series of neur-electro-magnetic corpuscles constituting a nerve, thus rendering this corpuscle positive and waking it up, so to speak, from its inert to a kinetic state. This process now is thought to be indefinitely repeated, the pattern always progressing from the positive to the negative end of the line, from a higher to a lower electrical potential, exactly like in an electrical conductor.

And now, just as we speak of an electrical pressure in ordinary physics, so we may also in the case of stimulus-conveyance speak of a neur-pressure and assume a corresponding neur-pressure-pattern, inferring that the neur-vibration-frequency pattern is being transformed into a corresponding neur-pressure pattern at the very moment the potential is being established, when the first electron is being "knocked off" the first neur-electro-magnetic corpuscle of the nerve in question. Thus we have these new terms introduced: Neur-vibration-frequency pattern, neur-pressure pattern, neur-potential.

As soon now as this particular neur-pressure pattern arrives at its destination, namely that particular group of neurons which is concerned with the final reception and interpretation of the stimulus, it, the author infers, is immediately retransformed into the original neur-vibration-frequency pattern and is consciously recognized as such.

To explain consciousness on the basis of neur-electro-magnetic principles is another problem which confronts us in this connection. Consciousness may be said to be that state in which all nerve cells of the cortex of the human brain find themselves after they have emerged from an inert into a kinetic state which latter in turn is brought about by the normal periodic bathing of these cells with the proper amount of lymph necessary to render them kinetic. Whenever this wave of lymph circulation retreats after a certain period of more or less intense activity on the part of these cells, the latter drop back into unconsciousness or at least semi-consciousness and become inert or partly so.

Another task confronts us in the solving of the problem on a neur-electro-magnetic basis of how the "impulse" which marks the start of the reaction upon a stimulus is being created. And how does this impulse become such as to initiate the proper kind of reaction which the stimulus calls for?

In search for the right answer we have to go clear back to the very beginnings of reactions for the purpose of self-preservation, to the simplest reactions we can imagine; the reactions of an amoeba. Such simple reactions dissolve themselves into the two principle movements of a mass of protoplasm of the consistency of a colloid, vice versa, *expansion* and *contraction*. All other reactions are supposed to have developed from these two fundamental movements; developed in the same degree as nerves developed and began to arrange themselves into systems, these systems becoming more and more complicated *pari passu* with the more complicated division of labor in the struggle for existence. And as in biological colloids-chemistry expansion of a colloid may be brought about

by injection of certain acids, and on the other hand contraction by that of sodium chloride, and as in these bio-chemical fundamental movements of expansion and contraction ionization through electrolysis; and as electrification of the ultimate colloid units is brought about through this ionization process, thus leading to electrical reactions; so, on the other hand, we have a well founded right to assume that even the more complicated movements in the nature of nerve reactions may be looked upon as neur-electro-magnetic reactions rendered so through the ionization process. That is to say: Like the simplest mass of protoplasm may expand and contract in response to a physico-chemical stimulus for the sake of self-preservation, so even in the higher organisms, plants and animals, including man, alike, the impulse leading to a reaction upon a certain stimulus, may be traced back to and explained as a reaction of electrified atoms and groups of atoms—ions—, as we call them, upon each other. Thus the nature of the "impulse," that what starts a reaction upon a stimulus, is in the last analysis physico-chemical and more specifically electro-magnetic. And as each stimulus has its own particular pattern that becomes a pressure pattern, so also each "impulse" is supposed to have not only its own characteristic neur-vibration-frequency pattern but also its particular corresponding pressure pattern, into which the former is transformed, only to be RETRANSFORMED as the pressure pattern of the impulse reaches its final destination, the muscle. Also here we might say that we are confronted by an ionization process which brings about the creation of lactic acid besides ammonia, the former causing the contractile substance of the muscle fibres to shrink and thus to carry out or help in carrying out the movement, voluntary or mechanical, which has been tried out through the trial-and-error method during millions and trillions of years of adjustment and has been found to be the only correct movement in a given case.

And why should we shrink now from drawing the final conclusions by applying these very same neur-electro-magnetic principles to those most intricate and most elusive of all nerve reactions involved in the *thinking process*? Why should we, after having to the last "jota," so to speak, explained the more common nerve reactions on the basis of neur-electro-magnetic principles, why should we hesitate to also apply these very same principles to the reactions of what we are accustomed to call "thinking," the "learning-process," the "association-of-ideas process?" Are memory pictures, stored away in certain neurons of the cortex of the brain, the results of certain characteristic neur-vibration-frequency patterns of light and shade, of color, of odor, of form and so forth, and have all these various patterns combined to form that particular memory picture; does the accumulation and proper coordination of these patterns create a sensation; do a series of such sensations form a percept; does a collection of percepts create a concept; and do concepts go together to form an idea; does an association of ideas finally give rise to a thought, then how can we escape the final forceful conclusion that every thought in the last analysis is derived from millions upon millions of such original neur-vibration-frequency patterns?

We speak of a magnetic personality and we only mean in the everyday usage of the phrase a personality which is attractive, like a powerful magnet which cannot be resisted by an iron filing. But why, so we ask, can we not use this phrase in a *literal* sense, now that we have a clearer insight into the workings of the nervous system in general and the brain in particular? Why not say that such a personality is really magnetic with respect to another person with whom he or she comes in contact? Why not admit that REAL NEUR-ELECTRO-MAGNETISM comes into play when two individuals are irresistibly drawn toward each other? Why not admit that real neur-electro-magnetic waves radiate into space from

the brains of individuals and that these very waves may be intercepted and be received by other individuals whose brains are, so to speak, "tuned in" on the "wave length" of the others? Our almost daily experience in this respect tends to substantiate these inferences when we speak of "suggestions" in psychology, of "thought transmission," etc. What the author of this theory of neur-electro magnetic nerve-reactions including thinking can merely touch upon in these few minutes, he has more fully discussed in the manuscript of his theory and the interested hearer is referred to this source of information.

May it be stated in concluding that the subject as such is still in its embryonic stage of development. In order to further it a program of re-research has been drawn up by the author in the introductory pages of his manuscript under the titles: "What the Neur-Electro-Magnetic Theory of Nerve Reactions Proposes to Show," and "Analysis and Working Program of the Theory."

May I close with the words which conclude the first chapter of the manuscript, page 7: "It (the theory) pleads for the unreserved, unprejudiced and enthusiastic cooperation of the research man in these various branches of science (physiology, neurology, and physical chemistry as well as bio-chemistry), realizing that it is only through such unreserved and unstinted cooperation that the gigantic task can be accomplished."