

SUPPLEMENT TO "NATURE."

PHYSIOLOGICAL STIMULUS AND RESPONSE.

Comparative Electro-physiology. A Physico-physiological Study. By Prof. J. C. Bose. Pp. xliii + 760. (London: Longmans, Green and Co., 1907.) Price 15s. net.

IN sequence to his books on response in the living and non-living (1902) and plant response (1906), Prof. Chunder Bose has published a third volume on comparative electro-physiology. Prof. Bose has great ingenuity in device of experimental apparatus, fertility in initiating new lines of observation, and a clear style of setting forth his experimental results and theoretical deductions; nevertheless, we feel far from satisfied with his performance. He strives constantly to group every result he obtains under "some property of matter common and persistent in the living and non-living substance," and to explain by this assumed common underlying property the diverse phenomena of response which occur in metal wires, plant and animal tissues, on mechanical, thermal, or electrical excitation.

Prof. Bose says he started his investigations seven years ago in order to demonstrate this underlying unity, and we cannot help feeling that he has prejudged his phenomena, and, biassed by his philosophical conceptions, may select his experimental results and set before his reader those which confirm the main line of his argument. Using the photographic method of recording, and the galvanometer as the indicator of electrical response, he has published a series of figures, each one of which illustrates some argument in the text. No tables are given showing the number of experiments done or the failures and contrary results which occur in all lines of fresh investigation, and thus, while we feel grateful to Prof. Bose for suggesting fresh and fruitful lines of research, we must wait for confirmation by others of his many new and somewhat startling conclusions.

To instance some of these, Prof. Bose maintains that nerve, which is universally regarded as non-contractile, "is not only indisputably motile, but also that the investigation of its response by the mechanical method is capable of greater delicacy, and freedom from error, than that by the electrical." He demonstrates the contractility of nerve by means of the deflection of a spot of light reflected from a mirror attached to a light lever, thus obtaining magnification up to 100,000 times, but at the same time states that it can be demonstrated even by a light aluminium lever magnifying 50 times. This is contrary to the result of an English physiologist, who has, to our knowledge, tried a similar experiment. Here we have a definite assertion supported by many photographic curves and details of experiment, and one which, when tested by others, can enable us to arrive at a definite valuation of Prof. Bose's work. Such an independent valuation is required, as Prof. Bose and the English authorities on electrical physiology have been greatly at variance.

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Prof. Bose claims that the fibro-vascular bundles of plants, which can be isolated in long lengths from the frond of a fern or petiole of cauliflower, act as vegetable nerves, the response being in every respect similar to animal nerve, and being affected similarly by ether, alcohol, ammonia, carbon dioxide, tetanus, &c. He regards the fibro-vascular system which forms the venation of leaves as a "vast catchment basin" for the reception of light stimuli and their transmission to the parts of the plant which are in the dark. By this nervous system, he says, the tone of the whole plant is maintained. In regard to Pflüger's law of the polar effects of currents, Prof. Bose demonstrates photographs showing the like effects on plant and animal structures, but finds that "above and below a certain range of electromotive intensity the polar effects of currents are precisely opposite to those enunciated by Pflüger." He endeavours to prove that the response of nerve to excitation consists of a positive and a negative variation, and that the tones of sensation, pleasure and pain depend on the ascendancy of one or other variation. He seems to recognise no deficiencies in the galvanometric method, and is unaware or neglectful of the work done with the capillary electrometer and of the diphasic variations obtained with this instrument by Prof. Gotch. The galvanometer is far too inert an instrument to demonstrate the true electrical response of nerve. Prof. Bose says that

"all the diverse phenomena of response may be summarised in the two following formulæ:—(1) Excitatory response takes place by contraction and galvanometric negativity. (2) Increase of internal energy induces the opposite effect of expansion and galvanometric positivity."

"The first of these effects is simply demonstrated by direct excitation of an excitable tissue. In order to demonstrate the second, stimulus is applied at a distance from the responding point. In consequence of sudden local contraction at the receptive area, a wave of increased hydrostatic tension is transmitted with great rapidity. Energy is thus conveyed hydraulically, and at the distant point the transmitted effect induces expansion and galvanometric positivity. This is followed by the more slowly transmitted wave of true excitation, which on its arrival gives rise to the normal response of contraction and galvanometric negativity."

All we can say in criticism of this statement is that while it may be true for plant tissue, there is not a shadow of fact in favour of it holding good for muscle, and we must remain unconvinced by the evidence adduced by the author in favour of its holding good for nerve, until his experiments on the expansion and contraction of nerve have obtained confirmation.

Prof. Bose finds that a metallic wire, the stem of a plant, and a nerve when suddenly submitted to torsion give the same electrical response, and in consequence is led to make the following statement:—

"By the conception of matter itself, on the other hand, as possessed of sensibility—that is to say of molecular responsiveness, we attain an immediate accession of insight into those physical interactions

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which must furnish the terms of ultimate analysis . . . and are led to the discovery of the impressive continuity as existent between the responses of the most complex living and the simplest inorganic matter."

Sensibility is the power to feel, and is the function of the cerebral cortex of man, and also, we may assume justly from the similarity of the neuromuscular reactions, the function of the brain of the higher animals. That it is a function of the fish or frog brain we cannot affirm with any certainty. To ascribe it to a plant or wire is altogether unwarrantable.

A similar condition of molecular strain may be present in a wire, a plant stem, and a nerve fibre, and give the same electrical response, but this is not sensibility, and we even cannot conclude justly from the similarity of electrical response that the same mechanism is present.

Suppose we see a cloud of steam rising over the wall of a field. It may be from a traction engine, from a dung heap, or from a team of horses heated with ploughing. Observations on the direction of the current of steam, and on the effect of modifying agents upon it, will tell us nothing as to the nature of the chemical process which results in the manifestation of heat and the evaporation of water. Prof. Bose's philosophy seems almost capable of asserting that the similarity in direction of the steam current proves the sensibility, not only of the horses, but of all three structures.

Apart from these criticisms, there are in Prof. Bose's book a great many very interesting observations and ingenious methods of experimentation which will repay the reader's attention. In particular, his experiments on root pressure and the rise of sap; those by which he seeks to demonstrate that not only sensitive plants but all plants respond to excitation by variations in turgescence and electrical state; his comparison of the glandular structures of sundew and pitcher plants with animal glands; his demonstration of Dr. Waller's "blaze current" in a brominated lead plate and assertion that it cannot be regarded as a sign of life; his demonstration on the motile leaflets of *Biophytum* of the anodic and cathodic effects of the constant current, and the velocity of transmission of excitatory waves; his comparison of retentiveness of molecular change in metals with memory. In fact, the whole book abounds in interesting matter skilfully woven together, and would be recommended as of great value if it did not continually arouse our incredulity.

L. H.

THE STEREOSCOPE AND STEREOSCOPIC INSTRUMENTS.

Die binokularen Instrumente. By Moritz von Rohr. Pp. viii+223. (Berlin: Julius Springer, 1907.) Price 6 marks.

THE scientific staff of the Zeiss firm have of late years devoted much attention to the theory of binocular instruments, and to the development of methods of measurement depending on stereoscopic

vision. The impetus given by the successful realisation of the prism field-glass has carried them on to a more exact examination of the conditions under which binocular vision can be employed for the accurate determination of relative position, which has led to the design of a series of new instruments for surveying and other purposes, of which the stereocomparator is the most widely known.

The thoroughness with which the problem has been considered is sufficiently illustrated by the present work of von Rohr, who has already in his previous writings dealt very completely with the theory of vision by means of binocular instruments. This previous work he has now supplemented with an examination into the historical evolution of stereoscopic instruments, systematically planned with the view of clearing the ground and avoiding loss of labour from the re-development of ideas already investigated by previous workers. The book is divided into three parts; the first gives in a few pages a concise statement of the theory; then follows the history, to which part i. is merely an introduction; and the volume concludes with a most useful systematic summary of the matter contained in part ii., assisted by what may be described as a logical guide arranged in the form of a genealogical table, showing the subdivisions of the subject and referring to the place of treatment. This third part, of course, includes a bibliography.

The history begins seriously with the work of Ch. Wheatstone, who is even better known as an electrician. Reference is indeed made to some previous writers and instruments, from the early binocular of Lipperhey, and the suggestive experiments of R. Smith. One notices some omissions here, but the book makes no pretence to be exhaustive; the object is only to trace out the development of correct principles of construction, and to indicate the most important workers and the advances due to them. From this aspect the book is almost too thorough and complete.

Much space is devoted to the famous controversy between Sir David Brewster and Wheatstone, again because of its value for the development of the theory. It is now generally recognised that Wheatstone had the much more correct grasp of the principles, and that the popularity of the Brewster type of prism stereoscope as against the Wheatstone mirror instrument was due to its superior handiness, which outweighed its optical deficiencies. It is interesting to note that Brewster records the sale of prism stereoscopes from the time of the Great Exhibition to 1856 as amounting to more than half a million; these for the most part on the improved mechanical design of Duboscq. One can still remember the wide interest aroused by this method of obtaining pictures in relief.

The interest, however, soon died down, only to be revived in comparatively recent years. The simple stereoscope was gradually improved, as well as the binocular microscope, and more especially the binocular field-glass. The advances of photography were accompanied by the invention of various methods of obtaining "stereograms." But public interest only revived with Abbe's introduction of the prism binocular. Since then Jena has been the centre for the spread of renewed enthusiasm for the subject, while