fish backwards, the spines on the ridges of the disc come into action and tend to prevent any backward movement; and if the disc is forcibly pulled backwards the spines can be heard scraping over the surface. If pieces of twine are placed across the disc they prevent the formation of the necessary partial vacuum and the disc fails to adhere, while if the disc is adherent, the introduction of a finger-nail or the blade of a knife between the disc and the surface to which it is adhering allows air to enter and the hold of the sucker is immediately destroyed.

Further experiments were conducted in order to try to determine the strength of adherence of the sucker. In the first experiment, an Echeneis was allowed to attach itself to the enamel surface of a dish and a hook attached to a spring balance was passed through the gill from one side to the other. By standing on the dish and pulling on the spring balance, the amount of force could be fairly accurately measured, and in the specimen experimented with the fish withstood a vertical pull of more than 30 lb. before the hook tore through the tissues of the body. Further experiments were conducted by allowing the fish to attach itself to an enamel iron tray, the tray being fastened securely by rope to the spring balance. The balance was attached to a stanchion, and the head of the fish was seized in a towel to prevent the fingers from slipping on the skin of the fish. Two examples withstood a vertical pull of 34 and 35 lb. respectively before the sucker was pulled away from the surface.

It seems to me that there is little doubt that the disc acts as a true sucker by the creation of a partial vacuum, while the spines are of use in preventing this sucker from sliding on the surface of attachment. Thus, during life, when the Echeneis attaches itself to some other larger fish, it is owing to the partial vacuum formed that the disc adheres to the surface, while the spines prevent the Echeneis from being swept backwards by the rush as the large fish makes its way through the water.

A further point worth noting is that when the sucker is in action and the Echeneis is attached to any object, all movement of the fish, except that of the mouth and gills that is necessary for respiration, seems to be suspended and inhibited. The fish hangs absolutely motionless, and in the case of a fish that had been well hooked, it was found that by allowing the fish to attach itself to a glass plate it would hang motionless, while the hook and a great part of the fish's jaw was cut out! It appears that the action of the sucker causes inhibition of all movement of the body and tail.

In order to avoid any misapprehension, may I be allowed to add that my experiments were carried out at the suggestion of Dr. Hora, and the above notes, recording the results, were forwarded to him last January.

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R.I.M.S. *Investigator.*

Transmission of Stimuli in Plants.

AN article appears on the above subject in NATURE of October 25, in which reference is made to Mr. Snow's experiments (Proc. Roy. Soc., Series B, Vol. 96, No. 678) in support of Ricca's theory that conduction of stimulus in Mimosa is brought about by the transpiration-current in the wood carrying a hypothetical stimulating substance. Mr. Snow joins two cut pieces of stem of *Mimosa pudica* by a tube filled with water and applies a flame to the lower half of the stem with the result that the leaves of the upper half of the stem undergo a fall; hence it is concluded that stimulus is conducted across the water-gap. Mr. Snow also finds that the transpiration-current in Mimosa travels at about the same rate as the conducted excitation. I have carried out numerous experiments with this plant relating to the supposed transmission across a water column, taking the precaution that the heated air from the flame did not excite the upper leaves: other modes of stimulation were also used which were less open to sources of error. In no case did I find any evidence of the transmission of stimulus through the tube filled with water. This is confirmed by the results obtained by Prof. Koketsu last year, who found that when the petiole of Mimosa was cut into two halves, and rejoined by a water-tight tube filled with water, stimulus applied on the distal half was never conducted across the gap. (R. Koketsu, Journal of Department of Agriculture, Kyushu Imperial University, Vol. 1, p. 55, 1923.)

I also applied a chemical stimulant, and made a simultaneous determination of the rate of the transmitted excitation and of the rate of transport of the stimulating substance. The two rates are of very different order, that of the transmission of excitation being at least a hundred times the quicker. The slow transport of a stimulant or of a hormone, and the rapid transmission of excitation, ought not to be confused with each other. I have carried out numerous experiments which prove conclusively that the transpiration-current has nothing to do with the conduction of the excitatory impulse.

In the article referred to above, I find no reference to my earlier researches on the transmission of excitation in Mimosa, some of which were published so far back as eighteen years ago ("Plant Response," 1906; "An Automatic Method for the Investigation of Velocity of Transmission of Excitation in *Mimosa*," Phil. Trans., 204, B, 1913; "Irritability of Plants," 1913; "The Dia-heliotropic attitude of Leaves as determined by Transmitted Nervous Excitation," Proc. Roy. Soc., B, Vol. 93, 1922). These researches proved conclusively that the *conduction is a phenomenon of propagation of protoplasmic excitation.* This was proved by numerous experiments of a crucial character. Among these may be mentioned the characteristic polar effect of a constant current in protoplasmic excitation. I have shown that an excitatory impulse is initiated at the cathode at "make" and at the anode at "break" of the current, the excitatory impulse being afterwards transmitted to a distance. I have shown, moreover, that the interposition of an electrotonic block arrests the excitatory impulse in the conducting tissue of the plant as in the nerve of the animal. The above results have since been fully confirmed by Koketsu. The characteristic effects described above disprove the theory that the transpiration-current is concerned in the conduction of excitation. A full account of my more recent experiments will, I hope, be published shortly.

J. C. BOSE.

Bose Institute, Calcutta,
November 20.

An Approximation to the Probability Integral.

REFERRING to Prof. H. C. Plummer's letter on "An Approximation to the Probability Integral," published in NATURE of October 25, the following alternative way of representing the normal error function by simple approximation may be of interest. The original demonstration of this has been given by me in Physical Department Paper No. 8, "A Method of Curve Fitting."