ON REVERSAL OF GEOTROPISM IN ASTERINA

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(Accepted for publication, August 9, 1934)

I

The normally negative geotropism of Asterina gibbosa (Loeb, 1900; Mangold, 1909; Kalmus, 1929; Crozier, 1934–35) can be temporarily reversed to positive by mechanical stimulation due to handling, or stirring of the water (Crozier, 1934–35). The negative geotropism is unquestionably a response to tension upon the tube feet (Crozier, 1934–35); the sea-star can be forced to creep persistently downward by attaching to its dorsum a cork float, and the relation between angle of oriented movement and slope of surface is quantitatively described on the basis of this view. It was suggested that the reversal of geotropism following mechanical disturbance might be understood as an instance comparable to those in which “reversal of inhibition” brings about inversion of galvanotropism in echinoderms (Crozier, 1930) and certain other forms (Crozier, 1926–27).

This interpretation is tested by observing the geotropic performance of Asterina under the influence of strychnine, with and without cork floats attached. This particular test is necessary because in absence of a result with the added tension due to the float it could not be told whether one had to do merely with an effect of the strychnine in simply making the animal more sensitive to mechanical (tension) excitation.

In considering the effect of a drug (or other altered condition) upon an element of behavior it is necessary to keep it in mind that the influence of the reagent has a characteristic time course. It is only the question of reversal of geotropism which is of interest here, not the mode of action of the drug, but the time course varies with the concentration of strychnine and with the size of the Asterina. The inter-
val of developing strychninization within which it is possible to look for the evidence required is rather sharply limited. On the one hand, sufficient development of the effect of strychnine must be attained; on the other, the tests must be made before strychninization has advanced so far that the tube feet no longer attach to a substratum.

Sea-stars placed in dilute solutions of strychnine sulfate characteristically show dorsal flexure of the rays, with failure of attachment of the tube feet (Moore, 1918–19, 1919–20; Crozier, 1930), particularly when stimulated. This represents a reversal of the typical response. The galvanotropic orientation of the rays is with the oral surface toward the cathode, the rays being extended toward the cathode. The tube feet extend toward the anode; and creeping is in this direction. Under the influence of strychnine all this is quite reversed (Crozier, 1930). The effect of pilocarpine is similar, but not so pronounced. The reversal of galvanotropic response is accompanied by reversal of reaction to mechanical stimulation. Similar results hold for other forms (Crozier, 1926–27; Fries, 1927–28; Clarke and Wolf, 1932–33), and have been interpreted in terms of reversal of inhibition under strychnine.

Asterina in dilute strychnine sulfate reach a state in which the tube feet release attachment as result of application of even a slight touch or pressure; the rays and disc curve dorsally. Before this stage the tube feet may be caused to attach to a glass plate, although very slowly. They are then found to be positively geotropic, although progression is slow. Small wire hooks caught on the dorsum produce no change in the direction of creeping, despite the added weight. There is no reversal to negative geotropism as result of handling. If slightly more deeply under the influence of strychnine, such reversal to upward movement (temporarily) may be obtained by stirring the water with a glass rod. In some cases upward and downward movements alternate “spontaneously” for a short while. When emerging from strychninization, there is a period in which the now once more geonegative Asterina is very easily caused to become positively geotropic by agitation of the water.
The reversal to positive geotropism under the action of strychnine might be regarded as simply the result of "increasing irritability." But a small cork float may be attached to the hook in an Asterina's disc while creeping geopositively after being exposed to strychnine. The size of the cork is adjusted to give a moderate upward pull despite the weight of the hook. Without strychnine, or in an inappropriate phase of the action of the drug, the pull of the float leads to downward creeping (Crozier, 1934–35). It now results, however, in upward movement. Depressing the cork, or cutting the thread which holds it, leads to downward movement once more.

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There is thus a stage in the strychninization of Asterina during which the usual negative geotropism is reversed. The effect of an upward pull is also reversed. This accompanies reversal of response to touch, and must be regarded as involving reversal of inhibition. The effect of tension on the field of tube feet is normally to produce an orientation against the pull, no matter how strong it may be up to the point where the tube feet can no longer maintain attachment. Under strychnine this response is reversed. Consequently the reversal cannot be regarded as due merely to an intensification of the sensory effect of tension, but must be interpreted as due to a true reversal of inhibition in the coordination of effector movements, comparable to reversal of galvanotropism (Crozier, 1926–27; 1930). The temporary reversal of geotropism normally resulting after mechanical stimulation, which is a phenomenon seen in other forms also (e.g., Fraenkel, 1929), must be understood in the same way.

SUMMARY

A certain level of strychninization induces in Asterina reversal of geotropism from the normally geonegative movement to a persistent downward creeping. The effect of an attached float producing upward pull is to induce upward creeping, under these conditions, whereas normally it leads to downward movement. This reversal cannot be regarded as due to a mere intensification of the sensory effect of tension. It must be understood as representing a true revers-
versal of inhibition. The temporary reversal of geotropism following mechanical disturbances (in the absence of strychnine) is interpreted in the same way.

CITATIONS

Loeb, J., 1900, Comparative physiology of the brain, New York, Putnam's Sons.