"expressions of protoplasmic responses to definite stimulating agents."
The effect of adrenalin is the expression of the action of such an agent
from the blood. Ether inhibits the activities of the melanophores arrest-
ing them in whatever condition they may happen to be.

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THE DIVERSE EFFECTS OF ADRENA L IN UPON THE MIGRA-
TION OF THE SCALE PIGMENT AND THE RETINAL PIGMENT
IN THE FISH, FUNDULUS HETEROCLITUS, LINN

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Bigney ('19), working with the frog, found that the injection into the
blood stream of this animal of small quantities of adrenalin caused a
proximal migration (1) of the granules in the dermal melanophores of the
skin and a distal migration of the granules in the melanophores of the retina.
The present investigation was undertaken to determine if similar effects
were to be found in fishes.

For these experiments, the animal used was the common kilifish, Fundu-
lus heteroclitus Linn. This fish shows a marked response, both in the
scale (dermal) and the retinal melanophores to light and to darkness.
When it is placed in the light over a white background, it shows a prox-
imal migration of the scale melanophore granules and a distal migration of
the retinal melanophore granules. In the dark, these conditions are re-
versed, the scale melanophores showing a distal and the retinal melano-
phores a proximal migration.

The method adopted for stating the effects of the adrenalin upon the
retinal pigment was that of expressing the width of the retinal pigment ex-
tension, as measured along processes showing maximal extension in the
region measured, as a fraction of the total distance from the outer boundary
of the pigmented epithelium to the external limiting membrane, this dis-
tance being taken as 100. For purposes of brevity in this paper, the
terms light fish and dark fish will be used to indicate fish which have been
kept in the light and fish which have been kept in the dark, respectively.
In the typical light fish, the pigment shows an average extension of 83
units on this scale. Such light retinas show, in almost all cases, a secondary
concentration of pigment between 70 and 80. In dark animals, the average extension of the retinal pigment is 59, the pigment being massed at the outer region of the retina.

Retinas were examined of normal light fish, of normal dark fish, and of light and dark fish some of which had received intramuscular, some intra-abdominal injections of physiological salt solution, of adrenalin 1:1,000, or of adrenalin 1:10,000. The adrenalin used was that prepared by Parke Davis and Company and sold as "Adrenalin 1:1,000." The adrenalin was allowed to act for varying times before the retinas were fixed, with the results that the greatest effect was found to occur in those dark animals which had been injected with 0.2 cc. of adrenalin 1:1,000, and between thirty minutes and one hour after injection.

Of the animals to be experimented upon, those to be used as dark animals were kept in a photographic darkroom for at least sixteen hours before being treated; those to be used as light animals were placed in a white dish which was kept for at least a day by a north or west window and the fish were treated and killed between one and three o'clock in the afternoon. The animals were killed by quick decapitation with a pair of scissors, the head was opened longitudinally, and immersed in Bouin's picro-formol mixture. Fixation was allowed to proceed for about fifteen hours. The eyes were then dissected free from the head, washed thoroughly in 70% alcohol and dehydrated in 90% and absolute alcohol. While in absolute alcohol, the cornea of each eye was sliced off with a razor and the lens removed with a pair of fine forceps. The eyes were then cleared in xylol, infiltrated and imbedded in paraffin and serial sections were cut, in most cases 7 micra in thickness, and in a plane perpendicular to the face of the eye and through the optic nerve. Measurements could thus be made on radial sections at a point about half way from the entrance of the nerve to the outer rim of the retina. For measuring, a high dry objective and camera lucida were used, projection being made upon a line ruled along a sheet of paper and upon which the actual measurement was made. All experiments were performed at room temperature.

The results obtained are summarized in Table A. The values given in the table are the averages of all experiments for each class, plus or minus the probable error (P. E.) as obtained by the use of Bessel's formula. This probable error indicates the relative value of the results by taking into account not only the standard variation of each series but also the number of experiments performed.

It will be seen that when light animals are injected with 0.2 cc. of adrenalin 1:1,000, there is no significant change in the width of the pigmented region of the retina. In dark animals which had been injected into the body cavity with 0.2 cc. of adrenalin at the strength of 1:1,000, there was shown a marked change of the pigment position, the pigment
processes having an average extension of 77. Qualitative examination of these retinas showed a marked tendency toward the light condition. In these animals, however, the secondary, distal concentration of pigment was usually lacking. Injection into the abdominal cavity of weaker adrenalin solution, and injection into the dorsal musculature gave generally unsatisfactory results. Dark animals into whose body cavity physiological salt solution had been injected showed a barely significant change in the condition of the retinal pigment. Whether this very slight change is due to the effect of the physiological salt solution itself, or to the secretion of adrenalin by the animal remains to be determined. In all cases, the scale melanophores of animals injected with adrenalin showed the extreme proximal migration of the melanophore granules which has been described by previous workers.

Klett ('08), working with the frog, and using only light animals, was able to discover no effect upon the retinal pigment when a solution of adrenalin was injected into the blood stream. Injection of a very strong solution of adrenalin into the anterior chamber of the eye, however, caused a contraction of these melanophores. Bigney believes, and probably rightly, that this effect was due to the toxic nature of the solution used. Fujita ('11) used dark frogs and found that the injection of adrenalin into the bloodstream caused a distal migration of the retinal pigment. This finding was confirmed by Bigney.

Experiments upon Fundulus, here reported, demonstrate that the injection of adrenalin will cause a distal migration of the pigment processes in the retinas of dark animals, but produces no significant change in the already extended processes of light animals. The changes are of a reverse nature in the scale melanophores, the injection of adrenalin into the animal
causing a marked proximal migration of the granules. These findings are thus in accord with those of Fujita and Bigney in their work upon the frog, and opposed to those of Klett, also upon the frog.


1 Arey (’16) used the terms distal and proximal to designate the migration of the pigment granules away from the center of the melanophore cell and toward that center respectively. Hence a proximal migration would bring about what is ordinarily called the contracted condition of the melanophore and a distal migration the expanded condition.

A SIDE LINE IN THE IMPORTATION OF INSECT PARASITES OF INJURIOUS INSECTS FROM ONE COUNTRY TO ANOTHER

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Since the extraordinary initial success of the Department of Agriculture in importing the Australian ladybird beetle (Novius cardinalis) into California to destroy the fluted scale in the eighties, a great deal of successful work of the same sort has been done in different parts of the world. Most of these attempts have been made in a haphazard sort of way and a number of them have succeeded to a notable degree in spite of the rather unscientific way in which the importations were made and the lack of competent scientific study before the importations were attempted. The one thing which seems to have been rather carefully guarded from the start is the possibility of importing secondary parasites which might destroy the desirable assisted immigrants. Until recently there have seemed to be no time and no especial necessity for a careful biological study of the imported parasites before the importation has been attempted. Now in many cases such preliminary studies seem to be very necessary and they are being made.

One point which has undoubtedly resulted in the non-establishment of imported species has been the fact that in their native homes they had alternate hosts, feeding during one generation upon one species and during another generation upon another. Frequently the alternate host or a vicarious species has not existed in the country into which the parasites have been introduced.