is no heart beat. When the valves are open the heart rate averages somewhat over 20 beats per minute at 20° C.

When the entire upper valve of the oyster is removed the same stoppage of heart beat occurs at intervals. Oysters with the upper valves carefully removed will live for several weeks in running water, feeding and building extensive plates of new shell along the edges of the mantle. During feeding, when the mantle is expanded and the gills and cilia are active, the heart beats at the same rate as in oysters with windows in the upper valve. For periods of several hours a day each oyster is inactive; the mantle is contracted, the gills are contracted, carmine suspension placed upon the gills ir not moved, no feces are extruded, and the organism appears to be in a state comparable to a closed valve condition. There is no heart beat during these periods.

Studies were continued at the Mount Desert Island Biological Laboratory in July 1936 with observations on the soft shelled clam, *Mya arenaria*. The right valve was removed with as little injury to tissues as could be effected. The mantle over the pericardium was cut so as to expose the heart in its uninjured chamber. The organisms were kept in running water overnight before observations were begun. (Shock keeps them contracted and inactive for a long time after removal of the valve.)

The same heart conditions occur in the clam as in the half-shell oyster. When the siphons are extended with expanded tentacles and the incurrent and excurrent water exchange is taking place, the heart beats. When, during frequent periods in each day, the siphons are retracted, the tentacles inactive, and there is no perceptible water current, there is no heart beat.

The heart rate in the feeding clam with the valve removed is from 14-20 beats per minute at 13-14° C.

These observations may prove to be of considerable importance in a more extensive study of conditions in closed bivalves.

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## THE EFFECT OF TEMPERATURE ON THE ADAPTA-TION OF *FUNDULUS* TO BLACK AND TO WHITE BACKGROUNDS

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The rapid darkening of *Fundulus* when transferred from a light background to a dark one, and blanching when the reverse transfer is made, are well known reactions. It has been proved by many workers that the epidermal melanophores are chiefly concerned in the color change, that they are innervated through the central nervous system, and that the eyes are the important receptors. However, the relative rates of the two changes, the effects of temperature on the rates and the effects of rapid repetition of transfer from one background to the other have not been systematically investigated. Experiments were therefore conducted to throw light on these questions. About 800 tests were performed on *Fundulus heterochitus* in running sea water at controlled temperatures.

To increase uniformity of material only female fish of about the same size were used for the critical tests. The experimental dishes were lined with dead black paper or painted white. Sea water circulated through them at constant rate and temperature. When desired, the records of individuals were kept separately, the fish being identified by appropriate cuts in the tail fins. The experimental procedure was as follows. A fish from the stock aquarium was kept in the white dish until near-maximum blanching occurred. Notes describing its color and distinguishing markings were recorded. It was then transferred to the black dish. When nearmaximum darkening had occurred, notes on its color and markings were again recorded. The fish was then transferred successively to the white and to the black dish, and the times for blanching and for darkening to the same degree were recorded by a stop-watch. In some experiments as many as twenty successive transfers in each direction were made. For the final tests on the effect of temperature, the records of ten fish were kept separately for three color changes in each direction at eight temperatures.

An analysis of all the color changes recorded shows no real effect of repetition. In 31%, the rate of color change for successive transfers increased noticeably; in 28%, it decreased noticeably; and in 41% it remained constant. These variations were partly due to the uncontrolled internal and environmental conditions, and partly to the difficulty of the observer in correctly judging the end point. There was certainly no good evidence secured to substantiate the reports of Sumner (1911) and of Mast (1914) on the flounder that "the time required for adaptation is greatly reduced by practice." Evidently *Fundulus* differs from the flounder in this respect.

In all but a very few of the tests at all temperatures, the rate of blanching exceeded that of darkening. In other words, concentration of pigment within the melanophores proceeded faster than dispersion. This also differs from the results of Mast with the flounder, which darkens "much faster" than it blanches, and from the report on *Fundulus* by Parker (1936), who indicates that blanching requires more than twice as much time as darkening.

At temperatures of 0.0° and 30° C. the melanophores failed to respond to their backgrounds, the pigment remaining dispersed at the former temperature and lower, and concentrated at the latter temperature and above to the death point. As the temperature was raised from 0.0° to near 5.0° many fish showed increased rates of adaptation; others did not, but from 5.0° to 25° all fish showed increased rates when the temperature increased. Above 25.0° the dispersion rate decreased until near 30.0°, when the pigment re-

TABLE I.
The average times in minutes for adaptation to black (L-D) and to white (D-L) backgrounds for 3 tests
on each change on each of 10 fish to sight to write (0-10 packgrounds for 5 tests
the shange on each of to hish at eight temperatures +0.2° (

	$PE_{M} = 0.6745 \frac{\Sigma d^{2}}{\sqrt{n(n-1)}}$														
	8.0°		11.0°		14.5°		16.5°		20.0°		24.5°		28.0°		
No.	L-D	D-L	L-D	D-L	L-D	D-L	L-D	D-L	L-D	D-L	L-D	D-L	L-D	D-L	
1 2 3 4 5 6 7 8 9 10	22.3 23.1 14.2 18.9 12.3 19.4 12.4 25.3 24.0 27.2	$\begin{array}{r} 4.7\\ 8.0\\ 6.9\\ 6.0\\ 4.9\\ 6.7\\ 5.5\\ 6.7\\ 4.9\\ 6.3\end{array}$	11.0 11.1 9.9 9.9 12.5 10.7 11.0 9.8 11.6 7.1	3.4 2.7 3.8 2.7 3.1 3.9 4.1 3.5 2.4 3.9	8.9 8.9 6.6 7.3 5.4 6.4 6.8 6.6 9.1 8.7	2.5 2.9 2.3 3.7 3.7 3.5 2.8 2.8 1.9 2.3	7.1 8.3 6.3 8.7 4.2 5.9 8.5 6.7 8.8 12.2	1.9 2.9 2.9 3.1 2.9 3.6 3.6 2.3 2.6 2.6	4.7 4.1 4.3 5.3 7.1 5.8 5.0 5.2 7.5 4.0	$\begin{array}{c} 2.0 \\ 1.8 \\ 2.9 \\ 2.7 \\ 1.9 \\ 2.3 \\ 1.8 \\ 1.6 \\ 2.2 \\ 3.0 \end{array}$	$\begin{array}{r} 4.3\\ 5.6\\ 4.2\\ 4.9\\ 4.7\\ 5.8\\ 5.1\\ 4.6\\ 4.6\\ 3.3\end{array}$	1.7 0.83 2.2 1.8 1.5 1.9 1.4 1.6 1.0 2.2	14.5 10.6 18.5 11.9 12.5 18.6 10.4 9.3 12.0 20.2	1.7 0.97 1.8 1.2 1.7 0.82 1.3 1.0 1.0 2.1	
Ave. %*	19.9 5.6	6.1 3.6	10.5 1.9	3.4 3.5	7.5 3.6	2.8 4.6	7.7 5.8	2.8 3.9	5.3 4.7	2.2 4.5	4.7 4.0	1.6 5.6	13.8 6.0	1.4 6.4	

\* % indicates probable error of mean expressed as percent of the mean.

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mained concentrated. For the reverse change, however, increases in temperature between 5.0° and 30.0° always caused increased rates of concentration.

The average results obtained from three tests for each color change by each of ten fish at eight temperatures are given in Table 1. It will be noted that the variation in adaptation time, expressed by the probable error as percent of the mean, is high (from 1.9 to 6.4%). Some of it is undoubtedly due to the observer's error in judging the time when adaptation to background is complete. The remainder is due to differences in rate of adaptation for individual fish.

When the data are plotted according to the Arrhenius equation (log. 1/min. vs. 1/T), the points above 8.0° for the averages of the ten fish are unmistakably linear, except the one for 28.0° for darkening. The ordinate of that point is only slightly greater than the one for 8.0°, illustrating that rate of pigment dispersion above 25.0° decreases until near 30.0° when no dispersion at all occurs. The points for adaptation to white background (or for pigment concentration) lie above those for adaptation to black background (or for pigment dispersion), indicating that the concentration rate averages 2.7 times greater than the dispersion rate. The temperature characteristics calculated from the slopes of the lines are: 10,900 for dispersion and 9,700 for concentration. The first value may indicate that dispersion is closely associated with some respiratory process, since many oxidative reactions show temperature characteristics near 11,000 (Crozier, 1924-25). Below 11.0° the rate of adaptation to each background decreases more rapidly, as the temperature is lowered, than above 11.0°. Sufficient data for analysis at low temperatures were obtained only for 8.0° and indicate that the temperature characteristic for each color change is near 32,000.

### SUMMARY

For *Fundulus heteroclitus* at controlled temperatures in running sea water, 1) repetition of transfer from a dark to a light background and vice versa does not alter the rate of adaptation to the background; 2) the rate of pigment concentration or adaptation to white background is more than double the rate of pigment dispersion or adaptation to black background; 3) between  $5.0^{\circ}$  and  $25.0^{\circ}$  C. increase in temperature causes an increase in rate of adaptation to background; at  $0.0^{\circ}$  and  $30.0^{\circ}$  no adaptation occurs, the fish remaining dark and light respectively regardless of background; 4) temperature characteristics calculated from the Arrhenius equation are, for pigment concentration 9,700 between  $11.0^{\circ}$  and  $28.0^{\circ}$  C.; below  $11.0^{\circ}$ about 32,000; for pigment dispersion 10,900 between  $11.0^{\circ}$  and  $25.0^{\circ}$ ; below  $11.0^{\circ}$  about 32,000.

These results indicate that pigment concentration and dispersion are not simply reverse processes, but differ in some fundamental respect, and that temperature affects melanophoric adaptation in two different ways according to the temperature range. REFERENCES Crozier, W. J., 1924-25, J. Gen. Physiol., 7, 189. Mast, S. O., 1914, Bull. Bur. Fish., 34, 173. Parker, G. H., 1936, "Color Changes of Animals in Relation to Nervous Activity." (Chap. 3.) Philadelphia, Pa. Sumner, F. B., 1911, J. Exp. Zool., 10, 409.

# PRELIMINARY REPORT ON A NEW TUBULARIAN HYDROID

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A single species of an apparently hitherto undescribed genus of Tubularian hydroid was found in the waters off the Mount Desert



Island Biological Laboratory. (See Fig. 1.) It is a solitary mud-living form taken at between forty and sixty feet. The hydranth has a whorl of 6 to 8 oral tentacles and a whorl of 6 to 16 basal tentacles, the latter with rings of nematocysts along their length. Below the hydrauth the foot or tail is enveloped in a perisarc which is continued posteriorly in an irregular sticky sheath containing small ovoid bodies. The length of the hydroid exclusive of this sheath is about 5 mm. The medusae are formed in the region between the whorls of tentacles and have one tentacle in the immature stage observed.

FIG. 1.—The hydroid in expanded condition.

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