

much favour by the public, that it shows there is a great want for some rapid means of getting a limited number of copies of letters, &c.; and seeing that any number of colours may be used in the original drawing, Mr. Norman Lockyer has suggested that it would be of much use in laboratories, for the multiplication of original sketches of biological specimens, and even for spectra charts, and so save much of the time spent in making duplicate copies. The gelatin slab cannot be said to be perfect, as it is liable to be affected by atmospheric changes; but, bearing in mind the fact that the whole is simply a sponge filled with a compound capable of liquefying certain inks, it is reasonable to hope and expect that chromography is only the pioneer of a process, which shall possess all its advantages and none of its defects.

R. H. RIDOUT

THE ANIMAL HEAT OF FISHES

THE belief that fishes are *cold-blooded*, that is, that they take on the temperature of the water which surrounds them, with no power to resist it, and that they develop little or no animal heat themselves, is still held by many even scientific observers. This belief is based partly upon the well-authenticated fact that fishes have been frozen and thawed again into life; partly upon the statements of many travellers who have found them living in water of a very high temperature (Humboldt and Bonpland recording the highest, 210° F.); and further, that a thermometer inserted into the rectum of some living fish freshly drawn from the water has been repeatedly found to indicate temperature corresponding very closely to that of the water itself.

During the past summer, and in connection with the operations of the U.S. Fish Commission at Provincetown, Mass., Surgeon J. H. Kidder, of the U.S. Navy, was detailed to make some systematic observations upon the subject of fish-temperatures with a view to setting the question upon a secure basis of actual experiment. Thermometers were made expressly for the purpose by Mr. John Tagliaine, of New York, of unusual delicacy, registering about 10° F. each, and recording fifths of a degree. These were used in connection with Negretti and Zambra's deep-sea thermometers, and all the instruments were deduced to a single standard by frequent comparisons, so as to insure *relative* accuracy. The fish were taken with a line, and their temperatures observed at once, care being taken that no considerable change in temperature occurred during the time consumed in bringing the fish to the surface. The observed temperatures were then compared with that of the water as recorded by a Negretti-Zambra thermometer sunk to about the depth from which the fishes were taken. The first observations, made by inserting the thermometer into the rectum of the fish, agreed with the generally-received opinion, showing but little higher temperature than that of the surrounding water.

The mode of experiment was then somewhat modified. Considering the fact that the intestinal canal of a fish is in close contact with the thin and scarcely vascular walls of the abdomen, which is surrounded by the water in which the animal swims; and, further, that the arterial blood comes from the gills, where it has been spread out as thinly as possible and brought into the closest contact with the surrounding water—a process well calculated to cool it quickly to the same temperature—it follows that neither the interior of the rectum nor the arterial blood would appear to have the same value as representing the body-temperature in fishes that those parts possess in mammals and birds. It is rather in the venous circulation and the branchial artery that we should seek for the heat which must certainly be developed in the chemical processes of nutrition and waste, and in connection with active muscular movements. In the remaining experiments of the series—about ninety in number—the fish

was therefore opened at once, and the bulb of the thermometer inserted into the cavity of the heart, or branchial artery, with the results indicated in the following table, which shows the averages:—

Fish.	Temp. of surrounding water.	Rectum.	Venous blood.	Remarks.
Cod ... ..	39°-42	+ 0°98	+ 4°63	Spawning.
Haddock ... ..	"	+ 1°30	+ 5°30	
Hallock ... ..	42	+ 2°40	+ 4°50	Spawning.
Hake ... ..	"	+ 2°40	+ 9°80	
Bluefish ... ..	70-73 *	+ 0°25	+ 1°55	D. young from oviduct ... ..
Young mackerel † ...	65 *	+ 0°50	+ 1°70	
D. do. ( <i>Scorpaenidae</i> )    ... ..	60 *	—	+ 2°30 §	Oviducts contained mature young.
Sculpin ... ..	60 *	+ 0°80	+ 3°20	
Eel Pout ¶ ... ..	—	+ 3°00	+ 6°00	D. young from oviduct ... ..
Flounder ... ..	42	+ 3°00	+ 3°00	
Dogfish ... ..	42	+ 4°40	+ 12°00	
D. young from oviduct ... ..	42	—	+ 20°60	

It appears from these experiments that fishes do develop a measurable quantity of animal heat, which is more apparent during the spawning season, and much greater in elasmobranchs (as is to be expected from their more perfect digestive and assimilative apparatus) than in other fishes. It also appears that the measure of this animal heat is to be sought in the venous blood, and not in the intestinal canal or arterial blood.

The limits of this preliminary note will not permit us to go into an enumeration of the difficulties of observation or the measures taken to guard against the errors likely to attend them. Nor is the number of observations (ninety-five in all) sufficient to warrant the offering of these figures as a final statement of the *degree* of animal heat presented by the several fishes observed. All that can be said to be proved so far is the fact that fishes do manifest animal heat, and in considerable quantities, sufficient to warm again, to the extent of from 3° to 12°, blood that has been cooled in each circuit to the temperature of the surrounding water. Details will be given in the forthcoming report of the United States Fish Commission.

In the single instance of a lower temperature than that of the water, observed in five blue-fish, all taken on the same day, it may be that the individuals experimented on, being taken at the surface, had just come up from a much greater depth and colder stratum of water. There seems to be no conceivable provision by which a fish can maintain a temperature below that of the surrounding water, cooling by evaporation being out of the question. The young dogfish from its mother's oviduct showed a temperature 8° higher than that of the mother herself, for the obvious reason that its blood, not coming into contact with the water by its gills (the umbilical sac was still attached), was not cooled otherwise than mediately, through the blood of the mother.

NEW MODES OF SHOWING DIFFERENT CHARACTERISTICS OVER SMALL ARCS IN AZIMUTH FROM THE SAME LIGHT-HOUSE APPARATUS

WHERE a light on a rock or island has to illuminate constantly the whole horizon, the ordinary dioptric fixed apparatus is all that is required. But when, as at

\* Surface-swimmers + "Sinkers." † Stomach, through oesophagus.  
 § Temperature taken in blood flowing from heart, the organ being too small to admit the thermometer.  
 || This rare species, not seen in Massachusetts Bay for thirty years, appeared, young, at Provincetown last summer in considerable numbers.  
 ¶ *Zoarces anguillarvis*.  
 The sign "+" indicates excess, and "—" deficiency, as compared with temperature of water.