EMBRYOLOGY OF *ACMAEA TESTUDINALIS*

F. G. WALTON SMITH
Commonwealth Fund Fellow, London

As a result of the author's recent work on the development of *Patella vulgata,* it was considered desirable to carry out further investigations on the more primitive Gasteropoda, of which the limpet, *Acmaea,* is a particularly interesting, though not too widely distributed example. The species *A. testudinalis* is found on the east coast of North America, although it is confined to regions mostly to the north of Mount Desert Island. Nevertheless a partially successful attempt to collect a series of the larval stages was made while at the Mt. Desert laboratory, mainly by means of the artificial fertilization of the eggs, and the subsequent rearing of them in laboratory tanks. The eggs were obtainable until early in September, and a few of the larvae were reared to a stage just prior to metamorphosis, in plunger tanks supplied with sea water filtered through glass wool. A limited number of larvae were also obtained by the examination of the townettings from near Googins Ledge in Frenchman's Bay.

The egg of *Acmaea* was found to segment in a manner similar to that of *Patella,* and in fact, the general features of larval development bear the resemblance to those of *Patella* that is to be expected from a consideration of their close relationship. Important confirmation of some recently elucidated facts in the development of *Patella* was the main result of the preliminary investigations, but it is intended to follow up even more important points by the examination of further material next summer.

CHEMICAL STIMULATION OF *FUNDULUS HETEROCLITUS* BY OXALIC AND MALONIC ACIDS AS A FUNCTION OF TEMPERATURE

IRWIN W. SIZER, *Rutgers University*

Chemical stimulation has been investigated previously (BULL. MT. DESERT IS. BIOL. LAB., 1933, and 1934) by using the dicarboxylic acids as stimulating agents on the barnacle and *Fundulus.* A study of chemical stimulation of *Fundulus* as related to temperature should yield additional information concerning the underlying mechanism controlling stimulation. An analysis of the data is made in terms of the Arrhenius equation, $K_2 = K_1\ e^{\mu/2(1/T_1\ -\ 1/T_2)}$ where K_1 and K_2 are velocity constants, T_1 and T_2 the absolute temperatures, and μ is the energy of activation in calories of the catalyst of the reaction controlling the rate. The temperature characteristic, μ, is a measure of how rapidly the rate of a process changes with temperature and is itself independent of temperature. It may be determined by the slope of the line drawn through the experimental points when log rate of a process is plotted against 1/T.

The experimental procedure was the same as that described previously. The range of temperatures between 0 and 29°C., was studied;

at each experimental temperature the temperature was held constant to ± 0.1°C. Ample time was allowed the fish for adaptation at a given temperature. This time varied from a few minutes at room temperature to several hours at 0°C. For the fresh water tests .002N and .008N oxalic acid were used as stimulating agents on six fish. In salt water .002N oxalic, .004N and .002N malonic acid were used as stimulating agents on three fish. At every experimental temperature sixty reaction times were procured and an average taken.

Two or three different temperature characteristics were found for each acid solution over the temperature range investigated. At the critical temperatures there is a sharp transition from one thermal increment to another. The temperature characteristics obtained are as follows: 15,800; 19,400; 20,600; 24,100; 33,000; 48,000; 56,500; and 65,000. Stimulation by .002N and .008N oxalic in fresh water yields the same μ values. In salt water .004N and .002N malonic yield the same temperature characteristics. This indicates that for chemical stimulation by a given acid in a given environment the mechanism of reaction does not change with concentration. Both thermal increments and critical temperatures are different for stimulation by .002N oxalic in salt water and .002N and .008N oxalic in fresh water. While the mechanisms for stimulation are similar in both environments, as evidenced by the fact that parabolic equations relating rate of response to (H^+) are obtained in both cases, the chemical reactions governing the rate of response are different in the two cases. This difference in stimulation in salt and fresh water is doubtless correlated with the difference in ionic constitution of the two environments. Stimulation by oxalic and malonic acids in salt water yields distinctly different values. While the fundamental stimulation system is the same for the two acids, the controlling chemical reactions determining rate of response are different.

The μ values obtained are all above 15,000. This definitely rules out physical processes as controlling stimulation. While factors such as diffusion, surface tension, and adsorption may be involved in acid stimulation, they are not controlling factors determining rate of response. Several different temperature characteristics have been obtained for stimulation by oxalic and malonic acids. This indicates that stimulation does not depend upon a single process, but rather upon a series of interrelated chemical reactions, each with its own temperature characteristic. Under varying conditions (e.g. change of temperature, environment, or acid) different chemical reactions may become the slowest or controlling process which determines the rate of response.

The variability of response as measured by the probable error of the reaction time was found to be the same function of temperature as reaction time itself. When the reciprocal of probable error is related to $1/T$ straight lines may be drawn through the plotted points. The μ values calculated from the slopes of these lines are identical with those obtained when rate of response is plotted against $1/T$. Thus variation is a direct function of reaction time itself and is determined by the same catenary series of events which determine rate of response to stimulation.