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"Clock" Controlled Activity Rhythms in the Fruit Fly .

Recent studies in this laboratory on the daily rhythm of eclosion (*1*) in fruit flies of the genus *Drosophila* have shown that it is controlled by an interval timing device—or "clock"—that is temperature independent. It is well known that the locomotor activity of *Drosophila* adults in the field also exhibits a clear daily rhythm; activity is maximal in the evening just before sunset. A question of prime importance is whether the active period is determined by strictly exogenous factors such as light intensity, relative humidity, or temperature, or whether an internal biological timing device is involved.

Experiments in the field (*2*) have shown that temperature and humidity do not play a major role in the determination of active periods in *Drosophila.* However, it has been shown that the time and duration of active periods are correlated with definite ranges of light intensity. During the late afternoon, maximum activity occurred when the light intensity ranged between 100 ft-ca and 15 ft-ca.

To study the locomotor activity of *Drosophila* in the laboratory, a small cylindrical lucite chamber was devised with a grid of fine wires on the inside walls. Every other grid wire was connected to a common terminal. When a fly walks about in the chamber, it cannot help but short-circuit any two adjacent wires. This short circuit was detected with a high gain amplifier, and contacts per hour were translated into ink marks by an operations recorder. The virtue of this system lies in the ability of the instrument to record activity of flies under wide ranges of light intensity or even in total darkness.

Figure 1 shows the pattern of activity in *D. robusta* over a period of 7 days. Six male and six female flies were placed in the chamber with food, and the humidity of the chamber was maintained at a high level. The temperature was rigidly controlled at 21°C. For the first 4 days the flies were subjected to 12 hours of bright light (25 ft-ca incident reading) alternating with 12 hours of absolute darkness. At the onset of the fifth day, a very dim light (less than 1 ft-ca incident reading) was substituted for the bright lamp. This dim light was left on for the remainder of the experiment, and the alternating dark and bright light cycle was abolished. It can be seen that the active periods for the first 4 days were restricted to a few hours before the onset of darkness and that activity fell off abruptly when the lights suddenly went out. During the last 3 days, when the flies were in constant low light, the active periods spread to some degree, but the mean remained in phase with the previous 4 days.

These data strongly suggest that a biological "clock" is operative in determining the active periods for the flies. The absolute amount of activity declined during the last 3 days of the experiment; this was probably the result of the depressing effect of dim illumination. Previous experiments in which flies were subjected to several days in absolute darkness bear this out. The amount of activity in total darkness was so slight that no rhythm could be detected.

Besides the fact that a rhythm of activity persists under constant conditions of illumination, it is also interesting to note the pattern of activity during the first 4 days of alternating light and dark. The onset of the evening peaks occurred quite regularly at about 7 P.M. without reference to any gradual fluctuation in light intensity, temperature, or relative humidity as would exist in the field. It appears then, that under alternating light conditions where the lights are turned on and off abruptly, the commencement of activity is under "clock" control.

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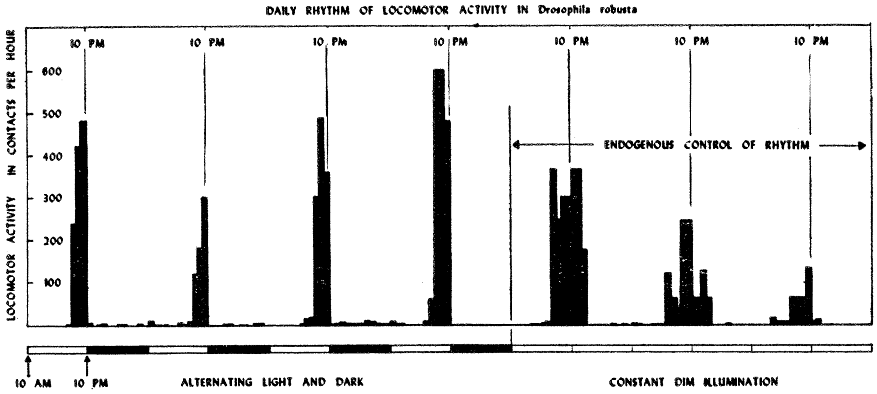

Fig. 1. Locomotor activity of *D. robusta,* six males and six females, over a period of 7 days at 21°C. Activity measured in contacts per hour. Contacts are made when a fly steps on a pair of grid wires. Under conditions of alternating light and dark, the photoperiods are 12 hours with "dawn" at 10 A.M. E.S.T.

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Hardness of Substances in the Ideal State

The relation proposed by Tabor (*1*) between Vickers indentation hardness, H_v, and ultimate tensile strength, T_u, of an ideal plastic material, $T_u = 0.33\ H_v$, may be used to calculate a hardness of the material in the ideal state since methods are known for calculating the "ideal ultimate tensile strength." The results of such calculations are interesting even though they may be considered only as approximations.

Griffith (*2*) has measured fracture strengths as large as 9×10^5 lb/in.^{2} for fine glass fibers as compared with a theoretical strength of 1.6×10^6 lb/in.^{2} and a measured strength of 2.49×10^4 lb/in.^{2} for rods of the same glass. The fine fibers have a strength of 633 kg/mm^2 and therefore a calculated Vickers hardness of 1900. This is equivalent to the hardness of corundum or a Moh's hardness of 9 as compared with about 4.5 for ordinary glass.

Herring and Galt (*3*) have measured the elastic properties of single perfect "whiskers" of tin and found a yield stress of 200,000 lb/in.^{2} The application of Tabor's equation yields a Vickers hardness of 141 for the whisker as compared with about 21 for hard drawn tin.

Zwicky (*4*) has calculated a strength of 200 kg/mm^2 for sodium chloride. The calculated Vickers hardness is 600, equivalent to a Moh's hardness of 5. The