during the summer of 1935. Seasonal movements of some animals, in connection with breeding or hibernation, may result in their greater destruction temporarily, but such killing is no basis for the estimation of a continuous daily rate of killing. Finally, let no sweeping conclusions as to the destructiveness of the automobile in respect to wildlife be drawn from such limited and variable observations as have been described here. The problem is in need of a systematic statistical survey covering several seasons and various localities.

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IS A PACEMAKER INVOLVED IN SYNCHRONOUS FLASHING OF FIREFLIES?

ONE hesitates to add another discussion to the long series already published on the fascinating problem of synchronous flashing of fireflies. The existence of this phenomenon in the tropical Orient is well established, and good descriptions of it have appeared in this journal[1,2] and elsewhere.[3] It is so easily observable in Siam that some of the efforts to explain it away are "more remarkable than the phenomenon itself."[2] However, my own observations suggest that the mechanism which maintains the synchrony involves a pacemaker, with stimulation through the light, a view not altogether in accord with previously published statements, but in agreement with a recent general interpretation of such phenomena.[4]

The phenomenon, during certain seasons,[1] may be readily observed from a boat in the Chao P'ya River between Bangkok and the sea. At some distance from the shore one may observe flashing in mangrove trees extending (at my estimate) for a quarter of a mile or more up and down the river. Although all the insects in these trees are flashing at the same frequency, and seem at first glance to be flashing in perfect unison, it has been my observation that each flash appears as a pulse of light that moves with great rapidity across the field of vision from one side to the other. In other words, in a long stretch of shore one may detect a slight *difference in time* of flashing (though *not in frequency*) between the insects that are some distance apart. My wife and others with me have verified this observation. Perhaps it could not be made satisfactorily in a small area, because, in spite of the high frequency (over ninety flashes per minute), all the trees visible at one time are darkened between consecutive flashes. In other words, if, as seems likely from this observation, a pacemaker stimulates the synchrony, the latent period of response to the stimulus by the individual insects is extremely short.

Morrison[1] pointed out two facts that are in accord with this interpretation, (1) the synchronism of the flashing may be inhibited by "exposing them [the fireflies] to a bright light for about a minute," and (2) "when the light is turned off, the synchronism returns, having its origin, apparently, in some individual or group generally located in the central part of the tree. From this group, then, the synchronism extends over the entire tree in an irregular wave until all of the insects are flashing in unison." However, he did not believe that the synchrony once established involved a pacemaker: "Furthermore, any follow-the-leader action on the part of the insects would result in a wave of light passing over the tree and originating from a definite point, a fact which is not the case once the synchronism has begun." What I have observed is this particular bit of crucial evidence—not a wave of light passing over a single tree, however, but a wave of light passing over a long row of trees.

Of some interest in connection with the suggestion of a permanent pacemaker are the experiments described by Hess.[5] In one of the rare observations of synchronous flashing of American species, in this case in a valley near Ithaca, New York, he found that he could initiate synchronous flashing by means of a pocket flashlight and even cause the insects to adopt a somewhat higher frequency.

It is not difficult to conceive of an internal mechanism which would make possible such a rhythmic behavior in a single individual. It might be some kind of recovery mechanism, as was early suggested.[6] A greater problem lies in the explanation of a synchrony which involves so many thousands of individuals; although, of course, a recovery mechanism may very well have a part in determining the frequency. A mechanism which is responsible for rhythmic behavior does not explain the synchronism of rhythmic behavior in different individuals. That seems to require an integrative factor. My own suggestion is that a pacemaker is a continuous as well as an initiating factor. In the absence of a pacemaker mechanism we should be forced to postulate the existence of an accurate physiological chronometer, a mechanism to most of us quite inconceivable.

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THE FIRST SCHOOL OF CHEMISTRY

I HAVE just been reading Thomas T. Read's short article[1] on the First School of Chemistry, in which he

[1] T. F. Morrison, SCIENCE, 69: 400–401, 1929.
[2] Hugh M. Smith, SCIENCE, 82: 151–152, 1935.
[3] T. F. Morrison, *Journal of the Siam Society, Natural History Supplement*, 7: 71–81, 1927.
[4] W. C. Allee, "Animal Aggregations," pp. 88–96. Chicago, 1931.
[5] W. N. Hess, *Biological Bulletin*, 38: 39–77, 1920.
[6] K. G. Blair, *Nature*, 96:411–415, 1915.
[1] SCIENCE, October 18, 1935, page 371.