of a third flash which followed CF by a constant 20 msec. All flashes were of 20-msec duration. A total of 15 "catch" trials were interspersed randomly among each block of 50 trials. Both subjects correctly reported which of the three single "catch" flashes had been presented on every one of these trials. Thus, it could be concluded that (i) variations in adaptation level during a session did not seriously influence flash detectability; (ii) reports on non-catch trials were not the outcome of guessing; and (iii) subjects had learned to identify a particular number with the appropriate stimulus area. On all trials, both the "catch," on which only one of the fields was presented, and the test, on which either two or three were presented, a "ready" was announced before presentation, no fixation patch was employed, and viewing was monocular.

The major results of the experiment are summarized in Fig. 1, which is a plot of the percentage of the trials on which the first flash (TF) was seen as a function of the TF-CF interval. Two functions are shown, one for trials containing two flashes only and one for trials on which the second flash was followed by a third. Since the data from the two subjects were essentially superimposable, they have been pooled. The results indicate marked facilitation of TF detection in the presence of a third flash. At those TF-CF intervals over which CF reliably backward-masks TF when no third flash followed, the detection of TF becomes reliable in the presence of a third flash. Further, CF was not detected on any of the "third flash present" trials. At the shortest TF-CF interval (25 msec), the

$\chi^2$ significance of the difference between corresponding points on the two detection functions is beyond $p = 0.01$.

While the present study reports data from only two subjects, the observed *disinhibitory* effect has been confirmed in a dozen others in pilot research incorporating the same features as those described. Because of the temporal range of the effect, cortical mechanisms may be considered. In this connection, I have reported elsewhere (8) reliable electroencephalographic correlates of peripheral spatial and temporal summation. Moreover, Donchin *et al.* (9) have demonstrated representation of two-flash summation, resolution, and inhibition in human cortical-evoked potentials. These findings, considered in the context of the present data, bring human psychophysical and gross electrophysiological data to bear upon spatiotemporal inhibitory processes so prominent in the *Limulus* visual system (10).

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doubt that the gravel deposit that yielded the skull is lower in elevation than the main Algonquin water plane and the gravels associated with that plane.

The gravel deposit is strongly cross-bedded and was built on what may have been an island or a headland in the glacial lake associated with the Ardtrea strand. There is evidence that deposition was extremely rapid, which rapidity would explain the excellent preservation of the skull.

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## Random Light and Wheel Running

Holmquest, Retiene, and Lipscomb found (1), in testing the effects of a random lighting regime on ten rats, that wheel-running measured as total group activity appeared to become desynchronized. They concluded that this was caused by the development of activity rhythms having periods shorter and longer than 24 hours and that random lighting modifies or nullifies the effect of light on mammalian biological rhythms.

An experiment which I have performed indicates that random light does not disrupt the activity rhythm of hamsters (*Mesocrietus auratus*) to any greater extent than constant light. The activity of five hamsters in individual cages equipped with running wheels was measured. The temperature was $19.5° \pm 1°C$, and the light intensity was about 11 lu/m². The animals were placed for 9 days on a cycle of 12 hours of light and 12 hours of darkness, and then they were exposed to random light. This differed from the random-light sequence of Holmquest *et al.* in that successive days did not have the same proportion of light and darkness and that the shortest light or dark period was 15 minutes instead of 1 hour. Random light was continued for 15 days, after which the hamsters were exposed to constant light for 17 days.

Under the 12:12 LD cycle all hamsters showed a nocturnal activity pat-

## Grizzly Bear Skull: Site of a Find Near Lake Simcoe

In 1965 Peterson (1) reported the find of a skull of a grizzly bear of the *Ursus arctos-horribilis* complex near Lake Simcoe, Ontario, aged 11,700 ± 250 years. "The specimen was discovered in a load of gravel removed from approximately 30 feet [9 m] below the local grade of a commercial gravel pit in November 1964." We visited the site in June 1965 and examined the shorelines associated with the stages of Glacial Lake Algonquin to determine which of the several water planes (2) corresponded with the gravel in which the skull was found.

The gravel pit, operated by J. and B.

Ennis, is situated on lot 12, concession II, Orillia Township, Simcoe County, just east of provincial highway 11. The deposit is poorly sorted coarse and fine gravel interbedded with sand and silt. The pit is well below a shore bluff that reaches approximately 251 m above sea level and is associated with the Ardtrea Beach as mapped by Deane (2)—the first well-pronounced beach below that of the main Algonquin shoreline which is here about 255 m above sea level. Standing at the site of the skull, one can look up to the main Algonquin Beach, which is well developed to the northwest. There is no

tern with a period length of 24 hours. Under random lighting, the individual hamsters showed increases of 22, 19, 27, 22, and 26 min/day (average, 23 min/day) in the period length of their activity rhythm. Continuous light resulted in a further increase in the period length for all hamsters; individual values were 26, 49, 40, 34, and 32 (average, 36 min/day), respectively.

Ashoff (2) has shown that the period length of many nocturnal animals' activity rhythm decreases with decreasing light intensity. The hamsters' activity rhythm (2) shows this phenomenon to a slight extent. The effects of random lighting on the hamsters' activity rhythm appear to be similar to the effects of constant light of a lower intensity. The difference between my results and those of Holmquest et al. may be the result of his measuring the rats as a group rather than as individuals, since the activity measured with one running wheel may not be a valid measurement of the group activity. All ten rats could not be in the running wheel at once, or, if they could be, no greater activity would be indicated than if only one rat was active. Social interactions could influence the rats' behavior toward the running wheel which would make the activity measurements difficult to interpret.

If the hypothesis of Holmquest et al. concerning the loss of rhythm synchronization is correct, it would seem simply that rats show individual variation in the period length of their circadian rhythm rather than that random light nullifies the effects of light on circadian rhythms. It also is premature to make statements about the effect of random light on mammals based on evidence from rats alone.

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Heckrotte's findings regarding individual activity rhythms in hamsters are interesting, and his comments on our conclusions are well taken. Our experiments were surveys of several morphological and physiological parameters, our data were taken from groups rather than individuals, and the data

trends were not definitive. Our hypothesis regarding the occurrence within the group of rhythms both greater and less than 24 hours in period was an attempt to account for an apparent drift of running activity and adrenal steroid peaks both forward and backward in time; and Heckrotte has provided contrary evidence on only one of these major rhythms. Although his data on individual rhythms are more definitive than those from a group, a complete comparison of results is hindered by his choice of a structurally different type of random lighting environment, our failure to state the intensity of our illumination, and the possible interspecies differences in response to light.

Our statements regarding a modified effect of light on biological rhythms were intended to point out the possibly unique, simultaneous coexistence of period lengths both greater and less than 24 hours within a group of rats in the same lighting environment, a finding which is in contrast to the generally uniform increase or decrease in period length which occurs under constant illumination as a function of light intensity. Our experiments did not deal specifically with this effect of light intensity on period length (described by Aschoff and others), although random lighting would be an excellent means of differentiating among effects of (i) light intensity, (ii) total duration of light per day, and (iii) the product of these two, the total radiant energy received per day.

The observation by Heckrotte of period lengths uniformly greater than 24 hours in running activity of hamsters, under random illumination, in a pattern similar to that found under constant light, is an interesting and significant finding; however, we would urge a measure of caution before one makes further comparisons between the two lighting environments. In a follow-up experiment on individual animals, we recorded telemetered intraperitoneal temperature from five adult male Sprague-Dawley rats which were kept for 7 days in a 12:12 LD environment (light intensity 34 to 60 lux, at floor of cage), 23 days in random lighting environment (prepared in similar fashion to that previously reported), and 11 days in darkness. Data from the least disrupted rat are charted (Fig. 1) in a manner similar to that from which running activity period lengths are
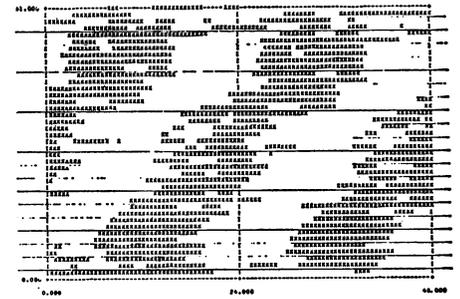


Fig. 1. Plotted points indicate those half-hour intervals for which body temperature is greater than the daily mean. The vertical lines are drawn at noon.
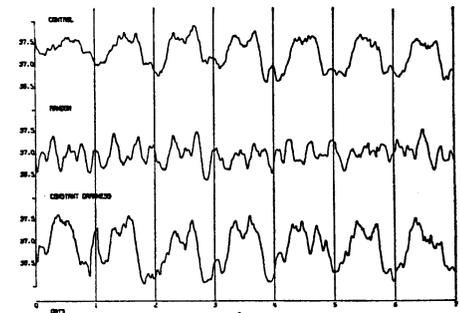


Fig. 2. Intraperitoneal temperature recordings from one rat, taken for three representative 7-day periods. Data recorded at 10-minute intervals and smoothed by moving average over 18 points. Vertical lines indicate noon each day.

classically determined. A period length of almost 25 hours is quite obvious. However, the actual temperature curves of a more typically disrupted rat show that random lighting has produced changes more dramatic than a mere shift in period length and more profound than those seen under constant conditions (Fig. 2).

Thus, we believe that a randomized lighting environment is vastly more complex in structure than a constant one, and comparisons between studies may be quite difficult. One must consider not only light intensity and the presence of background rhythmicities, but in addition the statistical distribution of light and dark period durations and the ratio of daily total light period to dark period. We should like to stress that there is more to the study of biological rhythms than the recording of period length.

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# Science

## Random Light and Wheel Running

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