responded to stimulation in a manner clearly indicating pain or fear. Unlike SS-P animals, however, high above-operant press rates could not be demonstrated at any current intensity in the regular 15-minute Skinner box test sessions. It is possible, however, that at least two of the five rats included in the U group could be appropriately placed in the SS-P group if manner, rather than rate, of bar-pressing is considered. Thus one of these animals, given a prolonged 200-minute test session, pressed at an average rate of only once per minute. Nevertheless, pressing did not occur at random. From Fig. 2 it can be seen that this animal with an electrode in dorsal central grey tended to press in clusters of about four at regular intervals. Moreover, the time between presses within a cluster tended toward constancy. In some clusters the intervals between each bar-press varied from 28 to 32 seconds. During these latter intervals the animal adopted a frozen posture, as if attending to some aftereffect of the stimulus. Probably the timing of responses within a cluster was closely tied to the duration of the aftereffect. The self-stimulation behavior of such animals seems no less significant than that of the SS-P animal which pressed 1100 times in a 15-minute session.

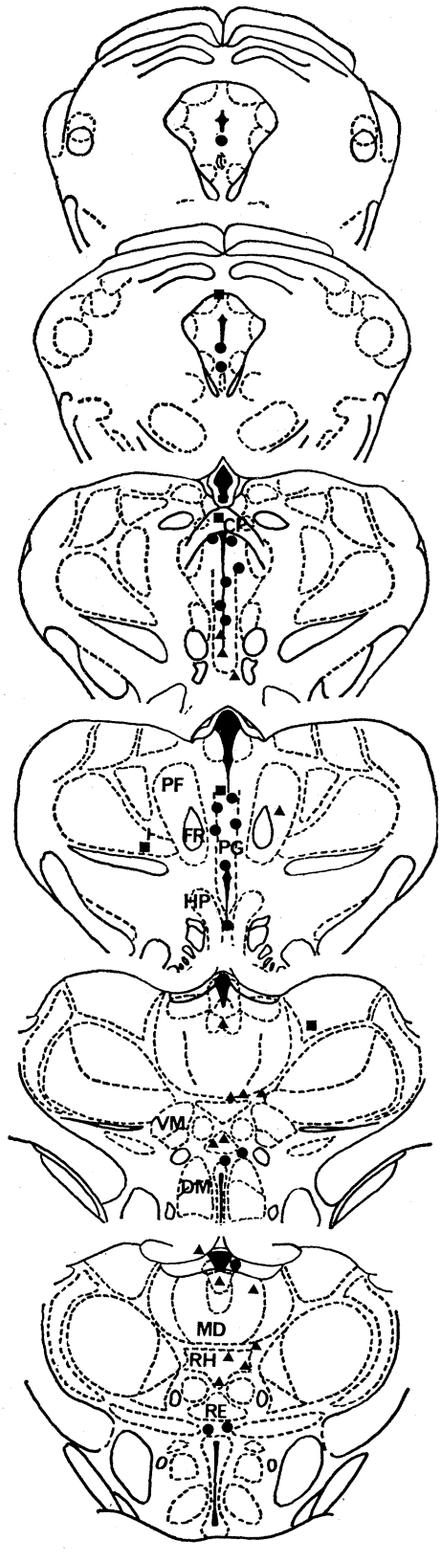

Fig. 3. Electrode tip locations of SS (triangle), SS-P (circle), and U (square) animals. Coronal sections slightly modified from König and Klippel (*11*).

At the conclusion of testing, the animals were killed and electrode placements (Fig. 3) were ascertained from cresyl violet or cresyl violet–luxol fast blue stained brain sections. The tips of the electrodes of several SS animals were located in centralis medialis, centralis lateralis, rhomboidalis, and reuniens, and one tip was located in nucleus parafascicularis. These SS placements correspond to nuclei making up the thalamic reticular system (*8*). Most SS-P placements were located in periventricular and central grey brain regions.

Functions proposed for the thalamic reticular system include sleep, consciousness, control of cortical rhythms, epilepsy, attention, learning, and nonspecific motivation. While such proposals are not mutually exclusive, such a long list seems compatible with our belief that there is little understanding of the functional significance of the thalamic reticular system. At the risk of adding to this list of supposed functions we feel that the present investigation indicates that the system is involved in specific motivational processes. Our contention is based on strong evidence indicating that self-stimulation always includes activation of specific motivational processes (*9*).

Many reports (for example, *4*, *6*) indicate that stimulation of the periventricular fibers and central grey is noxious. Experiments and theories have been based on the belief that self-stimulation cannot be obtained from electrodes implanted within this area (*6*, *10*). The present study indicates, however, that the self-stimulation effect is also consistently found in this region.

R. M. Cooper
L. H. Taylor

Department of Psychology,
University of Calgary,
Calgary, Alberta, Canada

References and Notes

1. W. R. Hess, *The Functional Organization of the Diencephalon* (Grune & Stratton, New York, 1957); H. Akimoto, N. Yamaguchi, K. Okabe, T. Nakagana, I. Nakamura, K. Abe, H. Torii, K. Mashahashi, *Folia Psychiat. Neurol. Japon.* **10**, 117 (1956).
2. W. W. Roberts, *J. Comp. Physiol. Psychol.* **55**, 191 (1962).
3. J. Olds, R. P. Travis, R. C. Schwing, *ibid.* **53**, 68 (1960).
4. M. E. Olds and J. Olds, *J. Comp. Neurol.* **120**, 259 (1963).
5. H. Mahut, *J. Comp. Physiol. Psychol.* **58**, 390 (1964).
6. A. Routtenberg and J. Olds, *ibid.* **62**, 250 (1966).
7. J. Olds and P. M. Milner, *ibid.* **47**, 419 (1954); R. M. Cooper and J. H. Bauer, *Can. J. Psychol.* **17**, 338 (1963).
8. H. H. Jasper, in *Handbook of Physiology*, Section 1, *Neurophysiology*, J. Field, H. W. Magoun, V. E. Hall, Eds. (American Physiological Soc., Washington, D.C., 1960), vol. 2, p. 1307.
9. J. A. Deutsch and C. I. Howarth, *Psychol. Rev.* **70**, 444 (1963).
10. J. Olds and M. Olds, *New Directions in Psychology II* (Holt, Rinehart and Winston, New York, 1965), p. 327.
11. J. F. R. König and R. A. Klippel, *The Rat Brain: A Stereotaxic Atlas of the Forebrain and Lower Parts of the Brain Stem* (Williams & Wilkins, Baltimore, 1963).
12. Supported by grant APA-135 from the National Research Council of Canada.

10 February 1967

Quasar 3C 446

Variations in optical light have been observed (*1*) in several quasi-stellar objects (quasars). Although no certain evidence has yet been obtained of variations within a month, the occurrence of fluctuations with shorter intervals has been suggested (*2*).

During the second week of October 1966 a photographic patrol of quasar 3C 446 was initiated at the Bethany Observing Station of Yale University Observatory, using the new 40-inch (1-m) telescope. This particular object was selected after Sandage's observation in July 1966 that it had brightened considerably since October 1964. This note announces our discovery of light variations having a considerably shorter period than the periods we have mentioned. Figure 1, covering a period of 2 months, shows significant variations in light over intervals of the order of 1 day.

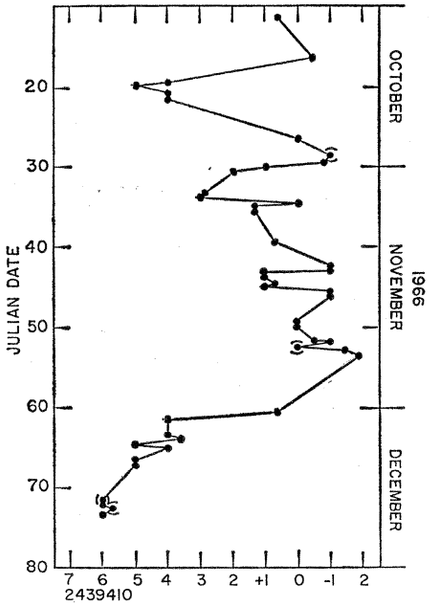

Fig. 1. Blue magnitude variations in quasar 3C 446. The abscissa is graduated arbitrarily; it spans a total of about 0.8 magnitude. The ordinate records the Julian date. Points in parentheses are uncertain.

Wherever possible, two plates were exposed during the same night. The exposures were all made with K 103a0 emulsion. The eye estimates, by use of three comparison stars, were made with a × 10 enlarging eyepiece.

Note added in proof. T. D. Kinman, Lick Observatory, informs us that his observations with the 120-inch (3-m) Lick reflector confirm that rapid light fluctuations occur in this object.

A. J. WESSELINK
J. HUNTER, JR.
Yale University Observatory,
Box 2023, Yale Station,
New Haven, Connecticut 06520

References and Notes

1. H. J. Smith, *Quasi Stellar Sources and Gravitation Collapse*, I. Robinson, A. Schild, E. L. Schucking, Eds. (Univ. of Chicago Press, Chicago, 1965), chap. 16; A. R. Sandage and J. D. Wyndham, *Astrophys. J.* **141**, 328 (1965).
2. D. W. Goldsmith and T. D. Kinman, *Astrophys. J.* **142**, 1693 (1965).
3. We thank J. Stordy for assistance in gathering the observational material.

21 November 1966

Ambiguities in the Use of the Term Circadian

The term *circadian* means different things to different people. One group of investigators uses it to denote *all* biologic rhythms with a period of about 24 hours (*1*). Another uses it to identify a special family of 24-hour rhythms, namely, those which have been shown to be generated by endogenous mechanisms, and which have a characteristic free-running cycle that changes in a predictable way when animals are kept in continuous light or darkness (*2, 3*). Some investigators believe that *all* 24-hour rhythms are also endogenous and potentially free-running. However, this assumption has not been supported by recent studies on the rat pineal gland. At least two cycles in this organ [hydroxyindole-*O*-methyl transferase activity and norepinephrine content (*4*)] appear to be generated by an exogenous sensory input (light).

The ambiguity which surrounds the use of *circadian* might not have been very important when this term was first introduced about 8 years ago (*1*). At that time, rhythm studies were largely concerned with functions that could be measured repeatedly in the same animal (such as cycles in body temperature, physical activity, and blood cortisol levels). These rhythms could be studied in individual animals that were blinded or kept in darkness, and the characteristics of their free-running periods could be defined without too much difficulty. By the time the rhythm was called *circadian*, it had generally been shown to be so in both senses of the word.

Now many investigators are performing another kind of rhythm study, in which the cyclic function is sampled only once in each experimental animal. In the typical experiment, rats are synchronized to a particular lighting schedule and are killed in groups, at intervals of 3 or 4 hours. A tissue is removed from each animal, and is assayed for its biochemical contents (as in *5*) or physiological activity in vitro (*6*). Data obtained from all of the animals that were killed at the same time are pooled. It is observed that the function passes through a maximum and a minimum value once during each 24-hour day.

It seems much more difficult to study the free-running characteristics of this type of rhythm than of one involving a function which can be monitored continuously. When rats are placed in continuous light or darkness (to deprive them of their external photic synchronizer), it cannot be assumed that as the cycle length changes all of the animals remain in phase. Even if they do remain synchronous, it is very difficult to demonstrate a small change (such as 15 minutes) in cycle length without killing vast numbers of animals. If the function is sampled at an inadequate number of intervals during the test day, it is possible that a rhythm whose period differs from 24 hours might be mistaken for one of that duration, just because a single high and a single low value were obtained at the times fortuitously chosen for sampling. Probably it will be a long time before it can be determined whether such tissue rhythms actually are *circadian* in the second sense (that is, they free-run with a period of about 24 hours).

If tissue rhythms are labeled *circadian* before appropriate experiments are performed to elicit their mechanisms, the ambiguities now present in the use of this term may prove troublesome. The casual reader who is accustomed to the more restrictive definition may draw several unwarranted conclusions from an article entitled "Circadian rhythms: Variation in sensitivity of isolated rat atria to acetylcholine." He may assume not only that cardiac responsiveness varies during the day, but also that this variability is the result of an endogenous mechanism whose free-running characteristics have been studied and found to share the characteristics of other well-known circadian systems [for example, the rhythm obeys Aschoff's rule (*2*)].

Perhaps the rhythms demonstrated by McGeer and McGeer, Rapoport *et al.* and Spoor and Jackson actually are *circadian* in either sense. Perhaps they are not. This should be explored in the laboratory. Meanwhile, it would probably be more appropriate to label all three of them "daily rhythms," or "24-hour rhythms."

RICHARD J. WURTMAN*
Laboratory of Clinical Science,
National Institute of Mental Health,
Bethesda, Maryland

References and Notes

1. F. Halberg, *Z. Vitamin-Hormon-Fermentforsch.* **10**, 225 (1959); ———, E. Halberg, C. P. Barnum, J. J. Bittner, in *Photoperiodism and Related Phenomena in Plants and Animals*, R. B. Withrow, Ed. (AAAS, Washington, D.C., 1959), p. 803.
2. J. Aschoff, *Cold Spring Harbor Symp. Quant. Biol.* **25**, 11 (1960).
3. C. S. Pittendrigh, *ibid.*, p. 159; ———, V. G. Bruce, N. S. Rosensweig, M. L. Rubin, *Nature* **184**, 169 (1959).
4. J. Axelrod, R. J. Wurtman, S. H. Snyder, *J. Biol. Chem.* **240**, 949 (1965); R. J. Wurtman, J. Axelrod, G. Sedvall, R. Y. Moore, unpublished observations.
5. E. G. McGeer and P. L. McGeer, *Science* **153**, 73 (1966); M. I. Rapoport *et al.*, *ibid.*, p. 1642.
6. R. P. Spoor and D. B. Jackson, *ibid.* **154**, 782 (1966).

* Present address: Massachusetts Institute of Technology, Cambridge.

22 December 1966