be almost completely destroyed. If these experimental findings are confirmed and if our reasoning is valid, the identification of these hypothetical substances (lipases ?, amines ?) might help clarify the time-honored relation of the kidney to arterial lesions.

Summary. Previous studies have shown that the combination of "standard high fat diet" plus "standard renal damage" resulted in typical arterial lesions in 36 of 40 dogs (90%). The data presented in this paper indicate: (1) "Standard high fat diet" plus damage to organs and tissues other than the kidney (chloroform injury to the liver, turpentine abscesses of subcutaneum, and bacterial infections) failed to produce arterial lesions and (2) "Standard high fat diet" plus renal insufficiency produced by bilateral ureteral ligation also failed to produce arterial lesions. These studies re-emphasize the importance of the kidney in the pathogenesis of necrotizing arteritis and indicate that azotemia *per se* is not the "renal factor". They suggest the possibility that the epithelium of the proximal convoluted tubules elaborates one or more substances necessary for the proper utilization of certain lipid substances.

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Diurnal Variations in the Mating Behavior of Male Rats.* (17337)

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Female albino rats usually come into estrus and display their most active mating behavior during the night;[1] and animals maintained under artificial illumination with a reversed light-dark cycle become receptive during the solar day.[2] The present investigation tested the hypothesis that a comparable rhythm of sexual responsiveness occurs in males of the same species.

Methods. Twenty-seven adult, virgin males of the Sprague-Dawley strain were divided into 2 groups that were kept in different halves of a windowless room which was bisected by a black curtain. From 11 P.M. to 11 A.M. one half of the room was dark and the other was illuminated by 2 100 watt bulbs. From 11 A.M. to 11 P.M. the lighting conditions in the two halves of the room were reversed. For approximately 3 weeks before testing began and throughout the remainder of the experiment all animals lived under identical conditions save for the fact that for Group I it was "day" from 11 P.M. to 11 A.M. and for Group II this same period was "night."

The first 2 mating tests were conducted between the hours of 3 P.M. and 7 P.M. The tests occurred, therefore, in the middle of the "night" as far as Group I was concerned, and in the middle of the "day" for Group II. The third and fourth tests were made from 3 A.M. to 7 A.M., thus reversing the temporal placement employed in tests 1 and 2. Mating tests for each male were spaced 3 days apart to allow for complete recovery from effects of sexual exercise. The stimulus animals were spayed, Sprague-Dawley females brought into heat by injection of estrogen and progesterone.† Methods of testing sexual behavior were the same as those employed by the senior author in previous studies.[3] A test lasted for 10 minutes if there was no coital behavior, and for 10 minutes from the time of the first complete or incomplete copulation if either response occurred.

Results. The experimental results are sum-

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1 Ball, J., *Comp. Psychol. Monogr.*, 1937, **14**, 1.

2 Beach, F. A., *J. Comp. Psychol.*, 1938, **26**, 355.

† The hormone preparations were generously supplied by Dr. Edward Henderson of Schering Corporation, Bloomfield, N. J.

3 Beach, F. A., *J. Exp. Zool.*, 1944, **97**, 249.

TABLE I.
Sexual Behavior of Two Groups of Male Rats Tested in Opposite Phases of Diurnal Light Cycle.

	Group I (N = 14)		Group II (N = 13)	
Measure of sexual performance	Tested in dark phase	Tested in light phase	Tested in light phase	Tested in dark phase
% of group copulating	85.7	71.4	23.1	92.3
% of group ejaculating	78.6	64.3	7.7	92.3
Avg frequency of copulation*	9.3	8.4	8.3	10.6
Avg frequency of ejaculation*	1.2	1.0	1.0	1.3
Avg seconds delay before first copulation	46.0	66.0	66.0	40.0

* Average frequencies based on performance of animals showing the response at least once in the test.

marized in Table I, which is based upon the average performance of each group during tests 2 and 4. Comparable group differences were apparent in the first and third tests, but it seems preferable to restrict our attention to behavior occurring in the second test of each series because this allows for preliminary adjustment to handling and testing during the particular phase of the light cycle that happens to be involved. The 14 animals in Group I were observed during the dark phase of the cycle in tests 1 and 2, whereas for the 13 males in Group II the first 2 tests occurred in the middle of the lighted portion of the 24-hour period. Group I was by far the most active sexually. Rats tested during the dark phase of the cycle were more likely to copulate and to ejaculate than animals placed with females in the light phase. And when coital behavior appeared it involved a higher frequency of intromissions and ejaculations in the case of the males tested during their "night." Considering only those animals that showed mating responses, the average latency, or delay preceding initiation of sexual contact was shorter for Group I than for Group II.

The time of testing was shifted by 12 hours during the third and fourth tests, and as a result the performance of animals in Group II improved appreciably. The proportion of the group showing copulatory responses increased by 69.2%, and the number reaching the point of ejaculation rose from 7.7 to 92.3%. The mean frequency of completed copulations and ejaculations increased, and the average duration of latencies was reduced. There is little doubt that most if not all of the increased sexual activity was due to changing the time of testing from the light to the dark phase of the diurnal light cycle.

Theoretically it might have been anticipated that the performance of Group I would deteriorate during the third and fourth tests, since at this time these animals were being tested during their "day." Some decrease in activity did occur and all changes were in the expected direction, but the scores remained well above those recorded for Group II during the first 2 tests. When Group I rats were shifted from "night" to "day" tests, the proportion of animals copulating at least once decreased, as did the percentage of the group achieving ejaculation. The average frequencies of copulations and ejaculations were similarly reduced, and the mean delay before initiation of sexual responses grew appreciably longer.

Discussion. Comparisons of the performance of the 2 experimental groups in test 2 fully confirms the hypothesis that male rats are sexually more active during the dark phase of their light-dark cycle. Care was taken to hold testing conditions constant for all males, and the females used as stimulus objects for the two groups were equally active and receptive. The pronounced change in the behavior of Group II animals when their tests were shifted from the light to the dark phase of

the artificial light cycle is added proof of the greater sexual potency during the "nocturnal" hours.

Female rats tend to come into heat during the night because of the associated rhythm of secretion of gonadal hormones. This rhythm in turn reflects the cyclic secretion of gonadotrophic hormones by the anterior pituitary, the functions of which are influenced by periodic increase and decrease in the amount of environmental illumination as well as concomitant changes in external temperature. Regular fluctuations in hypophyseal activity also affect the secretory behavior of the thyroid and probably of still other endocrine glands. As a result, the albino rat displays a diurnal rhythm of energy metabolism which begins to increase at approximately noon, reaches a maximum around 9 P.M. and progressively declines to the next noon. If rats are placed under constant illumination and fed at frequent intervals, the metabolic rhythm is abolished.[4]

There is no reason to believe that the rat testis secretes androgen at significantly different rates during different times of day, and even if it did so the behavioral response to alteration in the concentration of testicular hormone is too slow to account for the diurnal variations that characterize the male's mating performance. The heightened sexual excitability shown by male rats during the dark phase of the illumination cycle probably is due to the nocturnal increase in basal metabolism and to a consequent increase in responsiveness to all kinds of exteroceptive stimulation.

The sexual activity of males in Group I decreased only slightly when the time of testing was changed from the dark to the light phase of the 24-hour period. In all probability the continued high level of responsiveness was due to the effects of the first two tests when these animals were mated during their "night." In tests 1 and 2 the majority of Group I males gained a considerable amount of sexual experience. They became accustomed to receiving receptive females in the observation cage and achieved orgasm as a result of the subsequent copulatory contact. The resultant conditioning "carried over" to tests 3 and 4 and tended to compensate in part for the lower reactivity that usually obtains during the "day" segment of the diurnal cycle. Unfortunately it was necessary to begin the second series of tests within a week after the first series closed. An appreciably longer interval would probably have decreased the positive carry-over in Group I and produced appreciably lower sex scores for these animals when they were tested in the lighted phase of the illumination cycle.

Conclusions. Twenty-seven sexually-inexperienced male rats were maintained under artificial lighting conditions. The living cages were illuminated for 12 hours and darkened for a similar period. All animals were observed in mating tests with receptive females. Males tested during the dark phase of their diurnal cycle were much more active sexually than others tested in the lighted half of the period. When tests were shifted from the light to the dark phase, mating reactions increased promptly. In response to the reverse change sexual activity was reduced. Lowering of responsiveness which accompanied a shift from dark to light phase of the cycle was compensated in part by the effects of experience gained during previous tests conducted in the dark phase. It is concluded that the male rat's tendency to engage in sexual behavior is greater at night than in the day, and that the difference is probably due to the higher metabolic rate which characterizes the early nocturnal portion of the diurnal cycle.

[4] Murlin, J. R., *Ann. Rev. Physiol.*, 1939, **1**, 156.

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