

References and Notes

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Pineal Gland: Influence on Development of Copulation in Male Rats

Abstract. Male rats reared in constant darkness, pinealectomized 3 days after birth, and tested for copulation starting at 24 days of age, mounted receptive females more frequently and showed pelvic thrusting at an earlier age than littermate controls.

Early investigations (1) suggesting an inhibitory influence by the mammalian pineal gland on development of the genital system have been subsequently supported. Pinealectomy soon after birth produces an increase in the weights of the ovaries in the maturing female rat (2). Long-term administration of small doses of melatonin, a pineal hormone, to immature female rats decreases the weights of the ovaries, diminishes the incidence of estrus as judged by vaginal smears (3), and delays vaginal opening (4).

The inhibitory influence of environmental darkness on gonadal function in both male and female rodents is somehow mediated by the pineal gland (5). Normal development of testes and accessory organs is inhibited in maturing male rats whose eyes are removed, but this effect is blocked in blind subjects pinealectomized at 3 days of age (6). These experimental results suggest that, as in genital development, the development of male sex behavior in light-deprived animals might be hastened or accentuated by neonatal pinealectomy.

Male, hooded rats (Royal Victoria Hospital strain), born in total darkness within 14 consecutive days, served in the experiment performed from June to October 1967. Three days after birth, 16 male pups were pinealectomized, and 21 littermate males received sham op-

erations (6). Littermates were reared with their mothers until they were weaned at 21 days of age and were then housed two or three males to a cage. All animals were reared in the dark except for short behavioral testing periods under a 15-watt incandescent lamp.

Each subject was observed for 10 minutes in a semicircular Plexiglas box on alternate days beginning at 24 days of age. During a test the male was presented with a behaviorally receptive female (7) of comparable age and weight, and the number of mounts by which the male elicited a lordosis response in the female was recorded. The age of the male at initial occurrence of pelvic thrusting without actual intromission of the penis into the female vagina and, subsequently, the age at initial intromission were also recorded. When a male intromitted, the test was terminated before more intromissions occurred. At weaning, nine pinealectomized males and 17 sham-operated males had been randomly chosen for mating tests after initial intromission. These tests (8) began 2 days after a male first intromitted with a female and continued on every 4th day, except when a male failed to ejaculate during a test. In the latter case an animal was tested on alternate days until he ejaculated, whereupon the regular 4-day interval between tests was re-

instated. Again a receptive female was placed with a male for 10 minutes. If he intromitted during this period, he was allowed 30 additional minutes to ejaculate. A test was stopped after one ejaculation, and animals received approximately 20 mating tests. Both the age at which a male first ejaculated and the age at which an animal first copulated in "adult" fashion (ejaculated after no more than 15 intromissions) were recorded (8).

Pinealectomized males between 24 and 42 days of age (Fig. 1) mounted receptive females more frequently than sham-operated males ($F = 5.44$; d.f. = 1/35; $P < .05$). In subsequent tests (not shown) the group difference for males not yet intromitting gradually disappeared. Males in both groups mounted more frequently as they grew older. In conjunction with the increased mounting behavior, pinealectomized animals also showed pelvic thrusting toward receptive females at an earlier age than sham-operated controls. Fourteen out of 16 pinealectomized males initially showed the response at a median age of 32 days, whereas 13 out of 21 sham-operated animals showed the response at a median age of 49 days (two-tailed Mann-Whitney, $U = 46$, $P < .05$). Two pinealectomized and eight sham-operated males achieved initial intromission without showing earlier pelvic thrusting. Neonatal pinealectomy seemed to affect early components of the developing sex response in light-deprived males, but

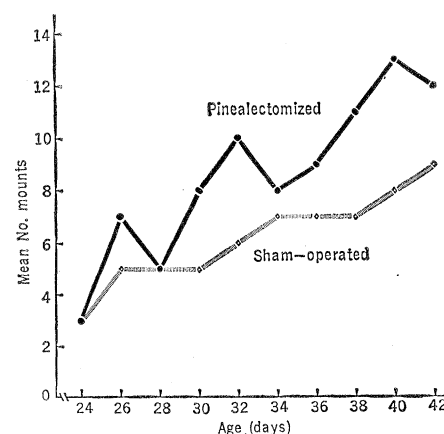


Fig. 1. Frequencies with which 16 pinealectomized and 21 sham-operated male rats mounted receptive females. Observations began when males were 24 days of age and continued on alternate days. Intromissions began to occur at 44 days in some subjects thereby ending this part of the testing for these animals. After 42 days the group difference in mount frequency for males not yet intromitting gradually disappeared (not shown).

subsequent events (intromission, ejaculation, adult copulation) were not influenced. Consequently, it is not possible to claim that pinealectomy advanced puberty, at least in the behavioral sense, in these animals.

Body weights obtained before each behavioral test showed no difference between pinealectomized and sham-operated males at any time during the experiment. Testicular weights for the two groups were not significantly different when animals were killed at 141 days of age. Histological examination of testes of animals in each group revealed no structural abnormality, and spermatogenesis appeared well advanced in all instances.

Pinealectomy may indirectly accentuate mounting and hasten pelvic thrusting by somehow allowing a temporary increase in secretion of androgens by the maturing testes of light-deprived males. Alternately, it is possible that pinealectomy affects these responses by acting directly on the preoptic and anterior hypothalamic structures necessary for normal copulation in male rats (9). Whatever the mechanism for its action, the pineal gland apparently influences only the early ontogeny of the male sex response and not the subsequent appearance of behavior patterns needed for reproduction.

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Organic Particles in the Ocean

To develop his model of the Precambrian environment and the development of life (1), Weyl assumed that particulate organic matter suspended in the Precambrian Sea sank and that some of it was concentrated on the permanent pycnocline. However, there is information from (other) studies which make this assumption doubtful.

The distribution of particulate organic matter in the sea does not appear to be influenced by density discontinuities (2). Instead, the distribution of this material seems to be controlled by circulation of water masses (3). Also, I have many unpublished data of concentrations of particulate organic carbon suspended in temperate and tropical areas over the shelf, slope, and basins of the Pacific and Atlantic oceans. Some of these were collected specifically to study the influence of the density structure of the sea on the distribution of organic particles. None of the data indicates that concentrations of particulate organic carbon are larger in, rather than above or below, seasonal and permanent pycnoclines. These results can be explained either if particles are not concentrated on pycnoclines, or if they are concentrated and are rapidly decomposed. The second explanation is unlikely because a decrease in concentration of dissolved oxygen at the pycnocline relative to the surrounding water should then occur and never is apparent. Thus the bulk density of the particulate organic matter in present seas must be different from that formed in the Precambrian Seas or one of Weyl's basic assumptions is incorrect.

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The observations on particulate organic matter in the ocean of the Present era show that this matter is produced at the sea surface, where the concentration, although patchy, is a maximum,

and that the concentration drops off with depth because of consumption by organisms. In the prebiotic, reducing ocean, there would have been no loss by feeding or oxidation, and hence the vertical distribution of the particulate organic matter would have been different. The paper by Menzel (1) gives a detailed vertical section of the concentration of particulate organic matter between South America and the Galápagos Islands; unfortunately data on the density-gradient layer is not included. Data for the months of interest (2) show that the mixed layer only extends to about 10 to 15 m, while the high concentrations of particulate organic matter in Menzel's data extend to, or below, 20 m, and in two instances show a peak in the upper part of the density-gradient layer in spite of consumption.

Whether organic aggregates will be concentrated by a density-gradient layer depends on their size and density. No data on the density distribution of organic aggregates is known to me. What one would really like to know is the size and density distribution of abiotically formed aggregates, whose size distribution has not been altered by possible passage through an organism. Concentration in the density-gradient layer will result if a significant fraction of the aggregates falls in the density range of the layer. The concentration of small aggregates that are denser than the range found in the density-gradient layer will also result from the reduced vertical turbulence in the layer. At the present time, this effect is masked by grazing, by the patchiness of production (1), and by possible consolidation as the aggregates pass through organisms.

My hypothesis would be refuted if experiments show that inorganic processes in a reducing sea do not produce organic aggregates whose rate of sinking would be significantly affected by the density-gradient layer. The vertical distribution of particulate organic matter at the present time must also be influenced by the density distribution in the water, although, as pointed out by Hobson, other factors seem to dominate.

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