

Effect of Ovariectomy on Basal Metabolic Rate of the Albino Rat.

CLARENCE R. MOTT. (Introduced by Con Fenning.)

From the Department of Pharmacology and Physiology, University of Utah School of Medicine, Salt Lake City, Utah.

Changes in the over-all body weight, and also the changes in the weights of various organs, following ovariectomy in the young albino rat, have been carefully studied, reported, and the literature reviewed by Freudenberg *et al.*¹⁻⁴

With respect to the metabolic changes, Hemmingsen,^{5,6} after reviewing the literature, states that the influence of ovariectomy on the metabolism of the rat has not been solved. Hemmingsen has reported the results of his own work on the effects of ovariectomy on metabolism of the rat and concluded that if there is a difference in the metabolic rate of the ovariectomized and control animal it is indeed slight.

In view of the results on growth reported by Freudenberg *et al.*, cited above, it would seem that one should reasonably expect a significant difference in the basal metabolic rate of the ovariectomized rats as compared with the controls if the comparisons were made at the proper time following ovariectomy. The physiological phenomenon associated with the marked acceleration in growth rate up to about 100 days in the ovariectomized animal should be accompanied by an increase in metabolism.

Experimental Procedure. Rats were selected at random, weaned and ovariectomized under ether anesthesia at the 26th day of age. Litter mates were used as controls. A laparotomy

was performed on the control animals, the ovaries being examined but not removed. Immediately following the operation the animals were placed in a constant temperature room in which the temperature was maintained between 28 and 29°C.

All metabolic measurements were made between 28-29°C as this temperature,⁷⁻⁹ is generally considered to be the critical temperature for the rat. A metabolimeter very similar to that used by Tainter,¹⁰ was employed.

In the biometrical analysis of the results to determine significance of changes the method given by Fisher,¹¹ for testing for the significance of two means was used. Rubner's,¹² formula was used in calculating the surface area of the animals.

Observations and Discussion. A statistical comparison of body weights (Table I) clearly shows that although the test animals were on the average heavier in all 4 age groups, the difference was not significant in the 40-60 day group, definitely significant in the 90-105 day group, only probably significant in the 175-210 day group, and not significant in the 800-840 day group.

The results in the first 3 age groups, with respect to changes in body weight following ovariectomy, compare favorably with those reported by Freudenberg *et al.*, as cited above. These authors did not extend their weight curves to include the older animals.

In the present study the average weight of the ovariectomized rats was at a maximum about the 40th week and then gradually de-

¹ Freudenberg, C. B., and Billeter, Oscar A., *Endocrinology*, 1935, **19**, 345.

² Freudenberg, C. B., and Howard, Philip M., *PROC. SOC. EXP. BIOL. AND MED.*, 1937, **36**, 144.

³ Freudenberg, C. B., and Hashimoto, E. I., *PROC. SOC. EXP. BIOL. AND MED.*, 1939, **41**, 530.

⁴ Freudenberg, C. B., and Hashimoto, E. I., *Am. J. Anat.*, 1937, **62**.

⁵ Hemmingsen, A. M., *Skand. Arch. Physiol.*, 1933, **67**, 137.

⁶ Hemmingsen, A. M., *Skand. Arch. Physiol.*, 1934, **68**, 89.

⁷ Goto, Kiko, *Biochem. Z.*, 1923, **135**, 107.

⁸ Wesson, L. G., *J. Nut.*, 1931, **3**, 503.

⁹ Sherwood, T. C., *J. Nut.*, 1936, **12**, 223.

¹⁰ Tainter, M. L., and Ryland, David A., *PROC. SOC. EXP. BIOL. AND MED.*, 1934, **32**, 361.

¹¹ Fisher: *Statistical Methods for Research Workers*, 5th Ed., 1934.

¹² Rubner, M., *Leipzig*, 1902, 281.

TABLE I.
Statistical Comparison of Body Weights and of Metabolic Rates.

Age group in days	Avg wt of controls g	Avg wt of ovari- ectomized g	Significance ratio	No. of con- trol rats	No. of ovariec- tomized rats	Controls cal*	Ovariecto- mized cal*	Signifi- cance ratio
40-60	80	85	1.2956	12	16	827	830	0.6890
90-105	142	163	4.5450	20	18	849	950	6.7428
175-210	177	195	1.6367	32	40	706	697	0.5100
800-840	220	221	0.0791	6	9	773	776	0.0876

* Calories per square meter of skin surface per 24 hours.

creased as the animals became older. The controls reached their maximum average weight about the 55th week which was followed by a gradual decrease. The difference in the average weights of the two groups became progressively less as the animals became older.

With respect to the changes in the metabolic rate (Table I) the difference was not significant in the 40-60 day group, definitely significant in the 90-105 day group, and not significant in the 175-210 or the 800-840 day groups.

It might be mentioned that a few metabolic determinations were made on these animals when they were around 150 days of age (results not included in above data), and, judging from the results of these few determinations, the mean heat production was about 50 calories per square meter of skin surface per 24 hr lower in the ovariectomized animals than in the controls. The author wonders if this is not the age when the deposited fat is greatest in the test animals and also possibly the time when those factors which are responsible for the accelerated rate of growth and metabolism in the 90-105 day group are beginning to exert less effect upon bodily functions. This point would bear further investigation.

It is interesting to note that the metabolism of the 800-840 day group was somewhat higher than in the 175-210 day group. This confirms the observation of Black,¹³ who reported a higher metabolic rate in 700 day old rats than

in those 7-8 months old. Benedict and MacLeod,¹⁴ also report that metabolism increases with an increase in age in the rat.

The complex relationship between the ovarian hormones and other hormones associated with growth and metabolism make it inadvisable to speculate as to the basic causes of the changes herein reported, but the work does point to a variety of experiments which may be designed to help improve our understanding of the basic phenomena noted. Studies on the effect of combined hypophysectomy and ovariectomy or combined thyroidectomy and ovariectomy are possible approaches, especially if combined with injections of pituitary or thyroid hormones with parallel studies on basal metabolism.

Conclusions. Following the removal of the ovaries in young rats (26th day of age) the animals will gain weight much faster than the control rats for the first few weeks and will remain heavier at least up to 800 days of age. During the growing period when the rate of growth of the ovariectomized rats is significantly greater than the controls the metabolic rate is significantly higher in the former than the latter. The metabolic rate of the normal and ovariectomized rat will be higher at 800 days of age than at 200 days of age, but less at either of these ages than at 90-105 days when growth is taking place most rapidly.

¹⁴ Benedict, F. G., and MacLeod, Grace, *J. Nut.*, 1929, **1**, 367.

¹³ Black, A., *J. Nut.*, 1939, **17**, 361.