10 days, but thereafter reverted to normal cycle while still spinning. This characteristic pattern was repeated in 3 rats out of 4. In group 2 (1.53 G) the tendency was similar but the diestrus was somewhat shorter. Again the pattern was repeated in 3 out of 4 rats. The same pattern was still evident in group 3 (1.39 G) in 5 out of 6 rats, but at a gravitation of 1.19 G or less (groups 4 and 5) the diestrus was not prolonged, and there was only a slight irregularity of the estrous cycles as compared to the stationary control (group 6). In experiment 2 the 8 rats that were spun for 40 days at 1.65 G showed during the last 10 days on the centrifuge normal estrous cycles. Upon return to ordinary gravity, these rats not only persisted in having normal estrous cycles but, from the start, the cycles were highly regular and in 5 out of the 8 rats they were even synchronous. Regularity of the cycles in the experimental group was in fact more precise than in the control group that had never been exposed to centrifugation.

Discussion. These experiments show that rats subjected to persistent moderate hypergravity enter a phase of prolonged diestrus. Within the range of 1.39–1.65 G, the length of the diestrus is positively correlated with the strength of the gravitational force but at a gravity of 1.19 G or less, there is only a slight irregularity of the cycle and no prolongation of the diestrus. We believe that this prolongation effect is purely due to hypergravity, because other kinds of stress, like food and water deprivation, immobilization or change of environment have been shown to produce effects of a different character and duration[7–10]. Moreover, other forms of stress would have had an equal effect on all the rats regardless of their position on the centrifuge, and this was not the case. Our findings are consistent with the changes observed in pregnant rats under similar conditions[3], and also confirm that there is a physiological adaptation with time in the gravity range used[5]. Results of the second experiment are particularly interesting in that they seem to show that a gravitational force of 1.65 G has a stabilizing and synchronizing effect on the estrous cycle of rats. Since this was the only hypergravity tested, it is not yet clear what is the minimal additional gravity and duration needed to induce the stabilizing and synchronizing effects. Further studies are now in progress concerning hormonal changes in rats under conditions of hypergravity[11].

7 E. F. Rosen and L. C. Petty, Physiol. Behav. *12*, 767 (1974).
8 D. M. Baldwin, J. A. Colombo and C. H. Sawyer, Am. J. Physiol. *226*, 1366 (1974).
9 D. M. Baldwin, J. A. Colombo and C. H. Sawyer, Pro. Soc. Exp. Biol. Med. *151*, 471 (1976).
10 S. Yonatani, M. Jojima and Y. Suzuki, Endocr. jap. *21*, 61 (1974).
11 Submitted by E. Megory as a partial fulfilment for the MD degree of Sackler School of Medicine Tel Aviv University.

Testicular blood flow and oxygen tension in unilaterally orchidectomized rats[1]

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Summary. Testicular blood flow was measured by means of Xenon-133 clearance and oxygen tension was measured polarographically in rats 3 weeks after unilateral orchidectomy. There was no difference between experimental and control groups for any of the two parameters.

We have recently shown that endocrine compensation in unilaterally orchidectomized rats (UOR) occurs within 3 weeks of the operation[2]. This compensation is not related to compensatory testicular hypertrophy (CTH), since CTH seems to be a result of the trophic action of FSH, rather than LH, on the seminiferous tubules[3]. Wurtman[4] has shown that LH increases ovarian blood flow and in 1950 Hartman et al.[5] developed a pregnancy test based on the vasodilatation response of rat testes to HCG. Furthermore it has been shown that there is a relationship between the arterial blood flow to the testis and its ability to secrete testosterone under the influence of HCG[6]. We have measured capillary blood flow in the remaining testis of UOR by means of Xenon-133 washout technique in order to establish if the observed endocrine compensation may be due to increased blood flow as a result of elevated LH concentrations[7].

Cross and Silver[8] used polarographically measured oxygen tension to study local and systemic mechanisms that appear to exercise a regulatory influence on testicular circulation. They stated that tissue oxygen tension is largely determined by capillary blood flow. In the present study, we have measured testicular oxygen tension to establish if there are any major metabolic changes in the

Testicular blood flow and oxygen tension in unilaterally orchidectomized and control rats

Method	Unilateral orchidectomy, $\bar{x} \pm$ SEM (n)	Controls, $\bar{x} \pm$ SEM (n)	Significance according to Wilcoxon's two-sample t-test based on range
Xenon-133 clearance (ml/min 100 g)	17.0 ± 1.2 (10)	17.1 ± 1.2 (10)	n.s.
Oxygen tension (pO_2 mm Hg)	21.6 ± 4.0 (7)	17.4 ± 2.1 (8)	n.s.

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2 S. Lindgren, J.-E. Damber and H. Carstensen, Life Sci. *18*, 1203 (1976).
3 V. D. Ramirez and C. H. Sawyer, Endocrinology *94*, 475 (1974).
4 R. J. Wurtman, Endocrinology *75*, 927 (1964).
5 C. G. Hartman, N. Millman and J. Stavorski, Fert. Steril. *1*, 443 (1975).
6 K. B. Eik-Nes, Can. J. Physiol. Pharmac. *42*, 671 (1964).
7 B. E. Howland and K. R. Skinner, Hormone Res. *6*, 71 (1975).
8 B. A. Cross and I. A. Silver, J. Reprod. Fert. *3*, 377 (1962).

remaining testis after unilateral orchidectomy (UO). It is important to realize that, although oxygen tension gives a good picture of circulatory changes over short periods of continuous measurement, it is necessary to compare the results of oxygen tension measurements to a specific method of recording capillary blood flow, since increased circulation would presumably reestablish a normal oxygen tension over a long period of time and thus obscure metabolic changes.

Experimental. Animals. Male rats of the Sprague-Dawley strain (Møllegaard-Hansen, Ejby, Denmark) were kept in a controlled environment 14 days before UO, which was performed as described earlier[2], and an additional 20 days before blood flow measurements. Food and water were available ad libitum.

Xenon-133 clearance. Xenon-133 dissolved in sterile saline was obtained commercially (AB Atomenergi, Studsvik, Sweden). Approximately 20–40 μCi in 30–40 μl of saline was injected percutaneously into the testis with a gastight Hamilton syringe. A Na-I crystal detector (Friesecke-Hoepfner 421 A) was used with a 10 mm exit diameter collimator (Friesecke-Hoepfner 417 B) with a distance of approximately 20 cm between the crystal and the testicular surface. The detector was connected to a Friesecke-Hoepfner 49 A scaler and recording was made on a Hewlett-Packard 7172 A strip chart recorder.

After background subtraction recordings were plotted on semi-logarithmic paper, $t^1/_2$ was calculated from the washout curve and introduced into the following formula in order to obtain blood flow:

$$F = \frac{0.693 \times K \times 100}{t^1/_2}.$$

The partition coefficient K used was 0.7 as given by Wax[9].

Oxygen tension recording. Oxygen tension was measured polarographically as described by Cross and Silver[8]. Recording electrodes were made of 60 nm platinum wire coated with a single layer of glass. A scrotal incision was made and the electrode was inserted through the tunica albuginea. An indifferent silver/silver chloride electrode was inserted into the scrotal cavage via the incision. A polarizing voltage of 0.6 V was applied via the indifferent electrode, and the resultant minute current at the platinum cathode (proportional to the concentration of dissolved oxygen) was amplified and fed to a galvanometer and a Devices strip chart recorder. The mean value from 10 min of stable recording was introduced into a calibration curve, for conversion to oxygen tension values. Calibrations were made before and after each recording in order to avoid errors due to damage to the electrode. The results are presented in the table.

Conclusion. Statistical analysis revealed no significant differences in blood flow or oxygen tension between control rats and UOR. We conclude that no increase in testicular blood flow is detectable with the method used and furthermore that no major metabolic changes are detectable after UO in rats. It is, however, possible that minute changes in capillary blood flow or metabolic rate in the interstitial tissue may be sufficient to account for the endocrine compensation observed[1] since the Leydig cells of the rat testis occupy a mere 2% of the testicular volume[10], and that such minute changes are not detectable with any of the 2 methods used.

9 S. H. Wax, Invest. Urol. *9*, 167 (1971).
10 E. C. Roosen-Runge, Anat. Rec. *123*, 385 (1955).

Cyclic variations in luteinizing and follicle stimulating hormone excretion by male rabbits, indicating a male equivalent to the oestrous cycle

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Summary. Cyclic variations of the urinary concentrations of gonadotropins in the male rabbit have been demonstrated. The mean durations of the cycles, 5–7 days, are close to that of the oestrous cycle of the female rabbit.

Ever since the initial observations by Doggett[1] and Kihlström[2], a considerable amount of data has accumulated indicating that at least some male sexual functions vary cyclically, often with a cycle duration very close to that of the oestrous cycle of the same species. These aspects of male sexual physiology have been discussed at a recent conference[3]. Previously, the literature within this field was reviewed by Kihlström[4,5] amd Voss[6].

There are some observations indicating a hormonal regulation of this male cycle in rabbits[7–12] and in men[13–15]. Moreover, long-term studies have revealed cyclic variations in plasma testosterone[16] and testosterone excretion[17,18] in men. There are as yet no similar studies of gonadotropin levels. Because of the short-term pulsatile variation of gonadotropic hormone concentrations in blood[19,20], determinations of the urinary concentrations of these hormones are to be preferred in long-term studies. Therefore, urine was continuously collected from healthy 15 sexually mature male rabbits of different breeds daily for 7 weeks. The animals were individually caged and the urine was secured by means of a plastic foil, formed into a funnel below each cage. Every morning the volume of the past 24 h specimen was measured and 5 ml pipetted into a plastic tube, which was frozen at once for later analysis. The quantitative analysis of the gonadotropins LH and FSH in the urine was carried out using the radioimmunosorbent technique according to Wide et al.[21]. All specimens from each animal were analyzed simultaneously in duplicate, recording the radioactivity with an automatic gammacounter (Autowell, Pickers, USA). Power spectral analysis was performed using an electronic computer, looking for cyclic durations from 2 to 16 days. As seen from the table, all 15 rabbits show statistically significant cyclic variations in LH and/or FSH excretion. Besides, 6 rabbits also show a longer cycle superimposed upon the shorter one. One possible explanation of this phenomenon is that the shortest cycle, having the most narrow band width, is the primary one, the longer ones being multiples of the former. The mean duration of these shortest cycles is 5.1 (LH) and 6.7 days, respectively. Consequently, the present results strongly indicate a hormonal background to a male sexual cycle, corresponding to the female cycle in the rabbit. A full account of this work will be published elsewhere. Studies of the continuous variation of LH and FSH excretion from day to day in man are also in progess.