have been reared successfully. The heteromyids are more difficult. The Ord kangaroo rat, *Dipodomys ordii*, was judged to offer the best possibilities as a laboratory animal because of its gentle nature and the ease with which it could be maintained in captivity.

The standard techniques usually employed for breeding laboratory animals have required drastic modification to fit the ecological requirements and the specific behavior patterns of the kangaroo rat. In nature, each adult rat is thought to be solitary in habit and to defend its burrow and food caches against intrusion by other kangaroo rats and other species of rodents. This inherent behavior pattern has been the greatest obstacle to successful matings in captivity. The failure of trial-and-error techniques, including a number of unsuccessful cage designs, led to the study of the rat's behavior. It was obvious that in order to reproduce in nature, there must be a period during which the sexes are attractive instead of repugnant to each other. It was judged that this behavior would be associated with sex hormonal effects.

Work initiated in this laboratory by William P. Jollie (*2*) led to successful mating and the rearing of a brood of four. Daily vaginal smears, autopsies, and histological studies led Jollie to conclude that the female estrous cycles were of 5 or 6 days duration and that they occurred at least from early February to late June or early July. More recent studies have shown that some wild-trapped females contained embryos as early as December and January, and wild young rats have been found in September and October, indicating a more extended polyestrous period. Whether or not the male reproductive pattern is cyclical in response has not been established.

Jollie assumed that the estrum phase of the cycle (characterized by a heavy predominance of enucleated, cornified, squamous epithelium in the vaginal smear) signified the period when attraction might replace repugnance in the female. From examination of vaginal smears, he made several pairings when females were presumed to be receptive and was successful in obtaining one litter. This and one other litter resulting from breeding of a captive pair (*3*) comprise the reported successful attempts of breeding kangaroo rats in the laboratory.

Following Jollie's lead, further studies were made from 1 January to 1 October 1955, in which five wild-trapped females and five captive-reared females were used in studying the breeding procedures. They were held singly in separate metal mouse cages until they were deemed ready for mating. Then each female was introduced simultaneously with a male into a larger breeding pen (30 by 30 by 10 in.) in which neither had established territorial ownership. If compatible, they were left together for 1 to 5 days, depending on observed evidence of cohabitation or copulation, after which they were separated and returned to individual cages.

The disadvantages of using the vaginal smear technique for determining estrum were overcome by associating a characteristic swelling and inflammation of the vulva with the heat period. By this method, six of the females (three wild-trapped and three captive-reared) produced ten litters with a total of 30 young. The number of young in the litters ranged from two to four. The postnatal mortality rate was low and a good growth rate was observed.

A limited amount of data suggests that the gestation period is 29 to 30 days. The most accurate measurement occurred when the presence of what appeared to be a gelatinous plug was evident 20 hours after the male and female were paired. The animals were immediately separated, and 29 days later the female gave birth to four young.

Thus far, captivity has failed to alter appreciably the behavior patterns of kangaroo rats born in the laboratory. However, some litter mates have lived harmoniously in a cage for months without the usual strife and mortality. This suggests that the antagonistic behavior pattern that has kept production of these animals on an experimental level may be altered by selection of the more gregarious individuals from successive generations.

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References and Notes

1. This work was supported under contract No. DA-18-064-CML-2639 between the U.S. Army Chemical Corps and the University of Utah.
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27 June 1956

Relation between Weight-Lifting Totals and Body Weight

According to a suggestion of T. F. Young (*1*), the weight-lifting ability of a trained athlete may be expected to be proportional to the two-thirds power of his body weight. This follows immediately from the assumption that the length of a limb should be proportional to the cube root of the body weight and the cross-sectional area proportional to the two-thirds power of the body weight.

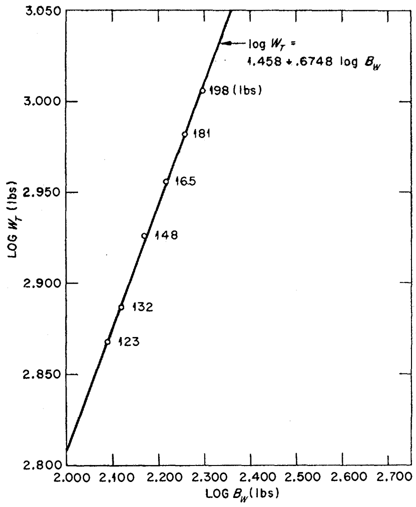

Fig. 1. Plot of log W_T (world-record weight-lifting total) versus log B_w (body-weight class).

If strength is proportional to the cross-sectional area of a limb or the torso, weight-lifting ability should be proportional to the two-thirds power of the body weight. Hence

$$W = a\, B_w^{2/3} \qquad (1)$$

where W is the weight that can be lifted in any one or in any combination of lifts, a is a constant, and B_w is the body weight. In order to test this relationship, it is convenient to express Eq. 1 in logarithmic form

$$\log W = \tfrac{2}{3} \log B_w + \log a \qquad (2)$$

Then a plot of log W versus log B_w should be linear, with a slope of approximately 2/3 or 0.67. Implied in the treatment is the assumption of constancy of form factor for weight lifters over the entire range of body-weight classes.

Weight-lifting championships are usually decided on the basis of the total weight lifted by an athlete in three different lifts: the press, the snatch, and the clean and jerk. Taking the total of the three lifts is effectively an averaging process, whereby the advantage one lifter might have over another because of more favorable leverage in one lift is counterbalanced in the other lifts. Hence, as a test of Eq. 2, the world-record totals in the three lifts mentioned should be better than the records in any one lift. Figure 1 shows a plot of log W_{T_i} (where W_{T_i} is the world-record total established at each body weight i) against log B_w. As can be seen, the points fall in a straight line as predicted. By the method of least squares, the best equation describing the points was obtained and is given as Eq. 3.

$$\log W_T = 1.458 + 0.6748 \log B_w \qquad (3)$$

The slope of the line, 0.6748, is very close to the predicted value of ⅔ and hence seems to bear out the theory.

In making the plot, only the totals for the body-weight classes up to 198 lb were used because the athletes in these classes are usually trained down to the listed body weight and hence carry very little excess weight. It is interesting to note that the present world-record heavyweight total of about 1130 lb should be within the ability of a lifter of 232-lb body-weight, whereas the present record holder, Anderson, weighs about 350 lb. The existence of the linear relationship also suggests that it might be desirable to break down the present heavyweight class into at least two classes to prevent lifters who weigh over 300 lb from competing with those in, for example, the 220- to 250-lb range.

It should be emphasized that the totals plotted are in no sense "ultimates" but will continue slowly to be improved. However, the slope of the line drawn through the points plotted on a log-log basis should continue to be approximately ⅔. Also, the log-log plot can be used to determine the best weight lifter at any time, since his total will fall the farthest above the line drawn by the method of least squares through all the records. At the present time, the total for the 148-lb body class falls the farthest above the line. Hence the Soviet athlete, Kostilev, who holds the record, appears to be at present the world's best weight lifter.

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1. T. F. Young, private communication.

28 May 1956

Surface Studies Using Ion-Exchange Autochromatography

The heterogeneous exchange between the ions on the surface of an ionic crystal and the ions in a solution has been widely used as the basis for a radioactive method for determining the "active" surface area of finely divided solids (for recent summaries, see Paneth, *1,* and Wahl and Bonner, *2*). Tracers isotopic with either the cation or the anion of the crystals may be used and should, on the basis of simple theory, yield the same calculated surface area. This is, indeed, the case in experiments in which labeled, saturated $PbSO_4$ solutions are shaken with $PbSO_4$ precipitates, but is not the case when saturated solutions containing $Sr^{90}S^{35}O_4$ are shaken with $SrSO_4$ precipitates (*3*). For the latter, the apparent areas, as determined using Sr^{90} ion and $S^{35}O_4^{--}$, are in the ratio of about 2/1. This difference is somewhat unexpected

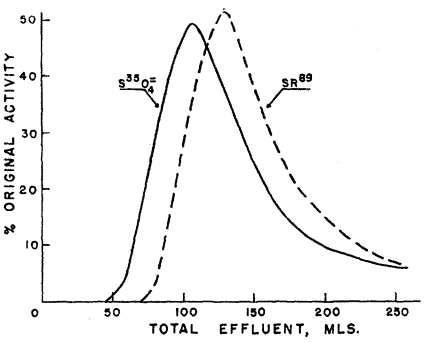

Fig. 1. Elution curve for Sr^{++} and SO_4^{--} using a $SrSO_4$ column at 25°C.

and seems large enough to warrant further study.

For this purpose a new method has been developed, the method of *ion-exchange autochromatography*. In a typical experiment, a Pyrex glass column of 1.2-cm inside diameter and 30 cm in length, contained 17.9 g of $SrSO_4$ precipitate in a length of 11 cm. The free volume was 8.75 ml. Fifty milliliters of $SrSO_4$ solution, saturated at 25°C and labeled with both Sr^{89} ion and $S^{35}O_4^{--}$ was added to the column. The column was then eluted with approximately 200 ml of saturated $SrSO_4$, and 50 successive 5-ml fractions of the effluent were collected. Suitable rates were obtained by applying suction to the bottom of the column. The column was jacketed and maintained at constant temperature.

The relative radioactivity of each sample was measured for both Sr^{89} ion and $S^{35}O_4^{--}$. Figure 1 is a typical elution curve obtained in this work for 25°C. It will be noted that the Sr^{++} and SO_4^{--} curves are separated and that the SO_4^{--} comes out ahead of the Sr^{++}. If a sufficiently long column were used, the two curves could be sufficiently displaced to make possible a reasonably complete separation of the Sr^{89} and $S^{35}O_4^{--}$ activities. Thus, when the chromatographic-column technique is applied, small differences in surface behavior can be accentuated (as compared with a single-batch experiment) and studied in detail. Further experiments varying the rate of flow of fluid, column length, temperature, and so on are in progress, and it is thought that the application of this sensitive new method will throw light on surface-exchange phenomena that are little understood at present.

By using two separately measurable isotopes, isotopic effects in surface exchange could also be studied and might be expected to be of considerable theoretical (and possibly practical) importance.

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25 June 1956

Influence of Invasiveness, Hormones, and Amphenone on Steroids in Adrenal Carcinoma

The study reported here (*1*) dealt with serial quantitative isolation of individual steroid hormone metabolites during the localized and metastatic phases of a functional adrenocortical carcinoma. It has been established that steroid production by the metastases is unequivocally increased by adrenocorticotrophic hormone (ACTH), probably decreased by exogenous cortisone, and markedly diminished by Amphenone [1,2-bis(*p*-aminophenyl) 2-methyl propanone-1 dihydrochloride] (*2*). This response is in contrast to the relative independence from extrinsic influence generally assumed to be characteristic of this form of malignancy.

In 1951, a 42-year-old woman was observed at Montefiore Hospital, with findings suggestive of adrenal hyperactivity, including amenorrhea, hirsutism, and hypertension. Isolation of urinary steroids (*3*) revealed (Fig. 1) normal levels of dehydroisoandrosterone (D) and androsterone (A), but etiocholanolone (E) and the three major 11-oxygenated steroids (11=OE, OH-E, and OH-A) were greatly elevated, demonstrating considerably increased adrenocortical hormone production. At surgical exploration, the left adrenal, containing an encapsulated tumor that weighed 140 g, was removed. The tumor showed bizarre cells and increased mitotic activity in focal areas. Postoperatively (Fig. 1), steroid isolation revealed a low level of hormone production, with the individual metabolites in the usual proportion, which was consistent with the clinical evidence of transient adrenal hypofunction.

In 1955, pronounced clinical evidence of adrenal hyperactivity emerged, and biopsy of intra-abdominal metastatic lesions showed adrenocortical carcinoma. At postmortem examination later, the right adrenal gland was normal. The urinary steroids were grossly altered compared with the localized phase (Fig. 1). The 11-oxygenated steroids were elevated to approximately 10 times normal levels, and the 11-desoxysteroids had changed even more strikingly. Androsterone had increased ten fold; etiocholanolone was approximately 30 times the normal level and, most striking of all, dehydroisoandrosterone (87 mg/day) had