LI. THE INFLUENCE OF CRYPTORCHIDISM ON THE GASEOUS AND NITROGENOUS METABOLISM OF RATS.

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THE chief difference between the testes of cryptorchid and of normal animals is the atrophy or complete disappearance of the seminiferous cells. In previous papers [Korenchevsky, 1930; Korenchevsky and Dennison, 1930] it was shown that most rats become obese after being made cryptorchid, although to a less degree than after castration. The development of obesity in cryptorchid animals was, therefore, ascribed mainly to atrophy of the seminiferous cells. Taking into consideration other data obtained it was suggested that the seminiferous cells (as well as Leydig's cells) produce testicular hormones and that the hormones of the seminiferous cells stimulate metabolism. An explanation was also offered as to why the degree of obesity developed by different cryptorchid and castrated animals varies, or, in some cases, is even absent [Korenchevsky, 1925, 1930].

PRESENT INVESTIGATION.

The aim of this investigation is to ascertain the influence of cryptorchidism on the metabolism, especially during the period of resorption of the seminiferous tissue from the testes of rats made cryptorchid. This period starts a few days after the operation and continues for different periods of time in rats of different ages, being completed in from 3 to 7 months. By the end of this period the testicular cells consist of Sertoli cells, in very atrophied tubules, and of well preserved or even hypertrophied Leydig's cells.

TECHNIQUE.

Successful experiments were performed on 10 rats, in 5 of which both the gaseous and nitrogenous metabolisms were investigated, and in the other 5 the nitrogen metabolism only. The technique used has been described in a previous paper [Korenchevsky and Dennison, 1932].

Before the operation the normal metabolism was investigated during a period of 2 days, and the investigation repeated 2 or 3 times at intervals of about 10 days. The animals were then made cryptorchid, after which the

metabolism was again investigated at different periods after operation, each time for 2 or more days. Only the averages of the results for each of the periods are given in the Tables.

The operation was performed in the same manner as in the previous investigation [Korenchevsky, 1930]. As can be seen from Table I, adult rats only were chosen. Those, however, used for gaseous and nitrogenous metabolism (first five, Table I) were older rats and, during the period of the experiment,

Table I. *Weight of rats (g.) during different periods after cryptorchidism.*

No. of rat	Normal period	No. of days after operation						
		6-17	20-29	33-38	42-59	69-84	122-136	196
986	334	332	333*	335*	336	—	—	—
1241	366	343	342	345*	348	—	—	—
1243	355	352	351	358*	363	366	—	—
1596	371	363	360	355	358	364	372	384
1597	365	361	361*	362	363	364	366	—
596	340	345	350	350	—	—	—	—
597	369	379	384	391	—	—	—	—
679	260	262	266	278	—	—	—	—
681	304	302	315	330	—	—	—	—
682	260	264	272	281	—	—	—	—
Average	332	330	333	339	—	—	—	—

* Interpolated from all available data.

increased in weight not at all or only very slowly. The remaining 5 rats, used only for nitrogenous metabolism, were younger and growing more rapidly. The food ration was smaller for the former rats than for the latter, being on the average 110 g. and 166 g. of paste respectively (per week per 200 g. of rat weight).

CHANGES IN METABOLISM.

As can be seen from Table II the gaseous metabolism definitely increased, the highest figures being obtained during the first two periods, *i.e.* from 6 to 38 days after the operation of cryptorchidism had been performed. This period coincides with the period of greatest resorption of the seminiferous cells, while they are still in abundance. After this maximum point the gaseous metabolism returned towards normal and, if the experiment were of sufficiently long duration (rat 1596), returned to the normal level. The respiratory quotient showed no great changes.

The nitrogenous metabolism (Table III) decreased slightly on the average during the period of increased gaseous metabolism. The nitrogen balance remained positive throughout, in some cases not only maintaining but even exceeding, the normal level.

Taking into consideration this fact and also that the weight, in spite of the constant food ration, was increasing in most cases, and in others was returning to or had reached normal, it must be admitted that the rats were growing. The nitrogen in this case must have been retained and used in the body chiefly for purposes of growth.

Table II. *Gaseous metabolism during different periods after cryptorchidism.*

No. of rat	Normal period	CO ₂ , O ₂ and H ₂ O in g. per week per 200 g. of rat weight.					
		Days after operation					
		6-17	20-38	42-59	69-84	122-136	196
Average H ₂ O excretion.							
986	90.4	109.2	103.6*	96.4	—	—	—
1241	89.7	104.1	111.8	93.5	—	—	—
1243	89.4	91.3	88.1	76.5	102.0	—	—
1596	109.8	103.3	112.2	113.6*	111.4	110.0	98.6
1597	103.9	103.6	101.6	99.2*	95.8	99.6	—
Average	96.6	102.3	103.5	95.8	—	—	—
Average CO ₂ excretion.							
986	52.4	58.4	57.0*	55.2	—	—	—
1241	60.7	65.2	66.3	63.4	—	—	—
1243	53.0	63.2	64.1	60.6	59.5	—	—
1596	61.5	63.7	64.6	64.3*	63.1	62.1	61.8
1597	59.6	64.0	63.7	63.6*	63.2	62.3	—
Average	59.4	62.9	63.1	61.4	—	—	—
Average O ₂ consumption.							
986	44.1	49.9	48.4*	46.8	—	—	—
1241	50.3	55.2	55.6	53.9	—	—	—
1243	49.0	53.0	54.2	51.4	49.8*	—	—
1596	50.9	51.9	54.4	53.9*	54.3	52.0	51.0
1597	48.9	53.5	54.5	53.8*	52.7	51.7	—
Average	48.6	52.7	53.4	52.0	—	—	—
Respiratory quotient.							
986	0.87	0.85	0.85*	0.86	—	—	—
1241	0.88	0.86	0.87	0.86	—	—	—
1243	0.86	0.87	0.86	0.86	0.87	—	—
1596	0.88	0.89	0.87	0.88*	0.85	0.87	0.89
1597	0.87	0.87	0.85	0.86*	0.88	0.88	—
Average	0.87	0.87	0.86	0.86	—	—	—

* Interpolated from all available data.

DISCUSSION.

The maximum increase of gaseous metabolism occurred during the period of greatest resorption of the seminiferous cells, while they were still abundant in the cryptorchid testes. This indicates that during the process of resorption substances were liberated from the seminiferous cells which stimulated the gaseous metabolism. It seems reasonable to suggest that these substances were hormones produced by the seminiferous cells. This conclusion is in agreement with the fact which was mentioned above, that most cryptorchid animals finally become obese if given food *ad libitum* [Korenchevsky, 1930].

There is one important disadvantage in experiments of very long duration on animals which are still growing, if the amount of food has to remain constant as is the case in metabolism experiments. With time the chemical composition of such animals changes, since the large stores of fat, carbohydrates, proteins

Table III. *Nitrogenous metabolism during different periods after cryptorchidism.*

N in g. per 200 g. rat weight per week.								
No. of rat	Normal period	No. of days after operation						
		6-17	20-29	33-38	42-59	69-84	122-136	159-196
Average N excretion in urine.								
986	1.05	0.98	1.00*	1.02*	1.05	—	—	—
1241	1.10	1.16	1.09	1.19*	1.26	—	—	—
1243	1.11	1.14	1.08	1.09*	1.09	1.06	—	—
1596	1.39	1.26	1.56	1.64	—	1.28	1.25	1.41
1597	1.79	1.60	1.61*	1.62	—	1.69	1.69	1.59
596	1.74	1.70	1.52	1.55	—	—	—	—
597	1.59	1.58	1.57	1.51	—	—	—	—
679	1.88	1.68	1.70	1.50	—	—	—	—
681	1.44	1.41	1.35	1.33	—	—	—	—
682	1.71	1.62	1.71	1.69	—	—	—	—
Average	1.48	1.41	1.42	1.41	—	—	—	—
Average N balance.								
986	+0.09	+0.16	+0.13*	+0.09*	+0.06	—	—	—
1241	+0.13	+0.14	+0.22	+0.09*	+0.01	—	—	—
1243	+0.19	+0.16	+0.22	+0.20*	+0.16	+0.19	—	—
1596	+0.25	+0.40	+0.11	+0.06	—	+0.42	+0.38	+0.13
1597	-0.09	+0.10	+0.09*	+0.08	—	+0.04	±0.00	+0.07
596	±0.00	-0.02	+0.14	+0.11	—	—	—	—
597	+0.16	+0.08	+0.08	+0.10	—	—	—	—
679	+0.10	+0.22	+0.18	+0.31	—	—	—	—
681	+0.25	+0.24	+0.23	+0.18	—	—	—	—
682	+0.17	+0.28	+0.14	+0.09	—	—	—	—
Average	+0.13	+0.18	+0.15	+0.13	—	—	—	—

* Interpolated from all available data.

and other constituents, deposited in the body during abundant feeding, are decreased or may even in some cases be exhausted. These are used for the most part for the purpose of building the growing tissues. The result is that the unit of weight of the animal at the beginning and end of the experiment is of a different nature, consisting at the beginning, to a considerable extent, of stores of fat, carbohydrate and protein, which are inert in the metabolism. By the end of the experiment these passive stores are converted into living cells which are very active in metabolic exchange, so that nearly the whole weight of the animal becomes active in its metabolism. In order that the animal may continue to live in a normal state, *i.e.* at the normal metabolic rate, for the same unit of its weight, only one way is available, namely, to reduce, if possible, its metabolism. Otherwise the weight will decrease, because the constant food supply will become insufficient for the increased amount of living tissues. Taking all these facts into consideration it must be admitted that the rats in these experiments, after being made cryptorchid, did in fact, by the end of the experiment, decrease their metabolism.

After the period of increased gaseous metabolism, due to abnormally great absorption of the hormones of the seminiferous cells, the weight of the animals returned towards or reached normal, and even in some cases increased; the

gaseous metabolism also returned towards or actually reached the normal value.

Moreover the nitrogen balance remained positive and in some cases even showed an increased nitrogen deposition, thus allowing growth of the tissues. All these metabolic changes occurred in spite of the constant quantity of food sufficient to maintain both the weight and the metabolism of the animal at a constant level, but not exceeding its needs. Thus the metabolism results corroborate the results obtained from the chemical investigation of rats [Korenchevsky and Dennison, 1930], when an increased amount of solids was found in the tissues of cryptorchid animals. This increase was explained by an increase in the deposition of fat and of nitrogenous substances.

The only probable explanation of these metabolic changes seems to be the decrease in metabolism due to the absence of the metabolism-stimulating hormones of the seminiferous cells.

If the ration of food is only sufficient for the equilibrium of the animal, there is a limit to the time during which even the decreased metabolism will satisfy the needs of the increasing amount of living tissue of the growing animal. We were, therefore, unable to keep the growing cryptorchid animals on the same amount of the same food for longer than about 10 months.

In order to obtain accurate results from such experiments as are mentioned above, care must be taken to find the right food ration, in quantity and quality, sufficient to maintain both the weight and metabolism of the animal at a constant level, but not to exceed its needs.

SUMMARY.

1. The gaseous and nitrogenous metabolisms before and after the operation of cryptorchidism were studied in 5 rats, and the nitrogenous metabolism only in another 5 rats. The period of observation lasted from 38 to 200 days after the operation.

2. An increase in the gaseous metabolism was observed during the period of most active and abundant resorption of the seminiferous cells from the cryptorchid testes.

3. This corroborates the suggestion made elsewhere as the result of other experiments, that the seminiferous cells secrete a testicular hormone which stimulates metabolism.

4. In all the rats, during the whole period of observation, in spite of the constant daily ration of food, deposition of nitrogen in the body was observed, in some rats remaining at or exceeding the normal level, even during the period of increased gaseous metabolism.

5. These data confirm the previous results of the chemical investigation of cryptorchid animals, in the tissues of which an increased amount of fat and of nitrogenous substances was noted.

6. Data are discussed which indicate a decreased metabolism in cryptorchid rats after the completion of the period of absorption of the seminiferous cells.

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