CXLVIII. NOTES ON SPERMINE.

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I. The identity of musculamine, neuridine and gerontine with spermine.

(*a*) *Musculamine.* Étard and Vila [1902] isolated this base as a benzoyl compound from hydrolysed calf's muscle, and gave it the formula $C_8H_{21}N_3$. Posternack [1902] pointed out the agreement of the analytical figures with $C_5H_{14}N_2$ and suggested the identity of musculamine with cadaverine, a suggestion which was afterwards adopted by Étard and Vila [1903]. We have obtained the same benzoyl compound from a dilute acetic acid extract of calf's muscle, but were unable to isolate it from the hydrolytic products of the extracted muscle. The substance is therefore not a cleavage product of muscle protein as previously assumed. Moreover we were able to identify the base as spermine by means of its characteristic insoluble phosphate, the picrate (M.P. 250°) and the chloroplatinate (M.P. 245°). The analytical figures given by Étard and Vila agree with the formula of spermine, $C_{10}H_{26}N_4$, as established by Dudley, M. C. Rosenheim and O. Rosenheim [1924].

(*b*) *Neuridine.* A base of the composition $C_5H_{14}N_2$ was obtained by Brieger [1885] from fresh human brain and named neuridine on account of its assumed relation to neurine. Its alleged occurrence amongst the products of putrefaction was no longer maintained by Brieger himself after his subsequent discovery of cadaverine (pentamethylenediamine), which has the same elementary composition. We prepared the base from fresh ox brain and found it to be identical with spermine (insoluble phosphate of characteristic crystalline form, chloroaurate, M.P. 225°). We are able to confirm Brieger's description of the properties of the picrate and its behaviour on heating, which furnish an additional proof of the identity of neuridine and spermine.

(*c*) *Gerontine.* In histological sections of dog's liver, Grandis [1889] found transparent, fairly insoluble crystals, which he isolated by mainly mechanical methods [1890] and identified as the phosphate of a base having the composition $C_5H_{14}N_2$. The chloroplatinate was analysed and a description of the picrate is given, unfortunately without its melting point. According to Grandis the base is not identical with pentamethylenediamine. Although we have not repeated the tedious mechanical isolation of the crystals, as described by

Grandis, we had no difficulty in obtaining similar crystals from dog's liver by the chemical methods previously described for the isolation of spermine phosphate [Dudley, M. C. Rosenheim and O. Rosenheim, 1924]. In spite of slight discrepancies in the described properties of gerontine and spermine, which may easily be due to the inherent difficulties of Grandis' method of isolation, we feel justified in considering the two bases as identical.

II. The distribution of spermine.

In our attempts to find a suitable material for the preparation of spermine in reasonable quantity, we carried out a number of experiments which furnish a fairly reliable picture of the distribution of this interesting base. Usually 3 to 5 kg. of material were worked up by one of the methods previously described [Dudley, M. C. Rosenheim and O. Rosenheim, 1924]. The figures given in the following table represent the actual yield of once recrystallised spermine phosphate, expressed in mg. per 100 g. of fresh material and arranged in the order of yield.

Semen (man)	260 mg. %	Testis (bull)	6 mg. %
„ (bull)	0	Thymus (calf)	5 „
Pancreas (ox)	25–30 „	Adrenal (ox)	5 „
Liver „	16 „	Thyroid „	3 „
Kidney „	15 „	Blood (ox) whole	0
Ovary (cow)	14 „	„ defibrinated	0
Muscle (calf)	12 „	„ serum	0
„ (sheep)	4 „		
„ (ox)	2 „	Milk (cow	0
„ (horse)	2 „	Egg (hen)	0
Spleen (ox)	11 „		
Lung „	7 „	Yeast (Lebedeff)	10 „
Brain „	7 „	„ (distillers)	7 „
		„ (marmite)*	40 „
		„ (baker's)	0

* The spermine content of "marmite" is very variable. The figure represents the maximum yield, whilst some batches contain only traces.

The absence of spermine from bull's semen is striking. We were unable to isolate it from 30 cc. of the material by the same method which yields weighable amounts when carried out with only 5 cc. of human semen [Rosenheim, 1924]. This result confirms the accuracy of the micro-chemical picric acid test (Barberio), which is negative with animal semen [Baecchi, 1912].

Apparently calf's muscle is richer in spermine than that of the fully grown animal. In the case of a six weeks old pig, however, we found no greater percentage of spermine in its tissues than occurred in those of an adult animal. The fact that the existence of spermine in muscle has been overlooked by Kutscher and his school is probably explained by their use of tannin for the preliminary purification of meat extracts.

III. The significance of spermine.

No systematic study of the physiological properties of spermine has yet been made, but such information as we have at present throws no light on the rôle of spermine in the organism. Its absence from bull's semen appears

to indicate that it is not essential for fertilisation in general, whilst the fact that it is not present either in the egg or in milk implies that it is not essential to the development and growth of the young animal. This view is supported by the result of an experiment carried out by Prof. J. C. Drummond, who found that spermine cannot replace vitamin B (yeast). Prof. R. A. Peters has performed some tests which prove that spermine, which is present in yeast, has no anti-neuritic activity, whilst Prof. A. Harden has informed us that experiments made to ascertain whether spermine phosphate could function as a co-enzyme in alcoholic fermentation yielded negative results.

Our best thanks are offered to these gentlemen for their kindness and interest in making the experiments and for their permission to quote the results.

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SUMMARY.

1. Spermine is shown to be identical with musculamine, neuridine and gerontine, bases which have been obtained from calf's muscle, human brain and dog's liver, respectively, by earlier investigators.

2. The yields of spermine obtained from various animal tissues and yeast are tabulated. It is shown to be absent from bull's semen, ox blood, cow's milk and hen's egg.

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