XVI. FURTHER EXPERIMENTS ON THE INFLUENCE OF THE PARENTS' DIET UPON THE YOUNG.

III. THE INFLUENCE UPON THE YOUNG OF AN EXCESSIVE AMOUNT OF CALCIUM IN THE MOTHER'S DIET DURING PREGNANCY.

BY VLADIMIR KORENCHEVSKY AND MARJORIE CARR.

From the Department of Experimental Pathology, Lister Institute.

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THIS is an addition to our previous communication [Korenchevsky and Carr, 1924] in which we omitted to take into consideration the results of some experiments we had published elsewhere [1923, 1]. In these experiments the mothers of 18 rats, belonging to three litters, Nos. 621, 624 and 646, were fed during pregnancy on N_1 (1 mother) or D_2 (2 mothers) diets (see Table, p. 113). Both these diets contained cod-liver oil. The calcium content of the former diet was adequate, but not excessive (0.26 % in fresh diet). In the latter most of the ingredients were given separately, and some in the form of paste (in particular cod-liver oil and calcium salts). Therefore, although this diet included calcium salts as well, the latter were ingested unevenly owing to the possibility of the rats selecting components of the diet poor in calcium. Roughly estimated, the rats consumed in this diet about the same amount of calcium as they did in N_1 diet, containing 0.26 % Ca.

In this paper the results obtained with these 3 litters are compared with those described in the previous paper, obtained with litters, whose mothers were fed during pregnancy on different diets. The diet of the mothers, though differing before and during pregnancy, was the same during lactation. The mothers during lactation, and the young rats after weaning, were fed on a diet deficient in fat-soluble factor (— A). The chief characteristics of the other diets mentioned in this communication are as follows. Diet N_2 was similar to the diet N_1 , but differed from the latter by containing twice the amount of calcium. Diet NB_3 contained three times the amount of calcium present in NB. In both these diets the only source of fat-soluble factor was butter. All the diets used except D_2 (see above) were given in the form of a paste, by which means the amount of each ingredient eaten could be measured accurately. The technique of the experiments and details of the diets were described in our previous communications [1923, 1; 1924].

The results obtained are set forth in the Table in average figures. They have led us to *modify to some extent the first and third conclusions in our previous paper* [1924].

There was no difference between the weight or the chemical composition of the skeleton of the NB and NB₃ groups of rats (see Table). Therefore, the addition of an excess of calcium to the normal diet (containing butter as the only source of fat-soluble factor), given to the mothers during pregnancy, did not improve the condition of the young nor diminish the severity of rachitic changes in their skeletons¹.

Table.

The influence of different diets of mothers during pregnancy upon the young.

The mother's diet during lactation as well as that of the young after weaning was deficient in fat-soluble factor.

Mother's diet during pregnancy	Amount of Ca % in fresh paste	Presence (+) or absence (-) of fat-soluble factor in the diet	No. of rats used for the average	Final weight of young in g.		H ₂ O %	In bones			
				♂	♀		Fresh Ca %	Dry Ca %		
<i>At the day of weaning (24 days old).</i>										
N ₂	0.52	+(cod-liver oil and butter)	10	38	34	58.4	6.2	15.0		
NB ₃	0.77	+(butter only)	4	34	34	62.2	4.8	12.7		
NB	0.26		63	31	30	61.4	5.0	12.7		
- A	0.26		5	19	19	68.3	2.6	8.2		
<i>When 65 days old.</i>										
N ₂	0.52	+(cod-liver oil and butter)	25	90	85	44.5	9.3	16.6		
N ₁ (or D ₂)	0.26	+(butter only)	18	55	44	48.4	6.4	12.4		
NB ₃	0.77		6	53	62	52.1	6.5	13.7		
NB	0.26		62	62	53	50.9	6.8	13.8		
Normal rats about 65 days old			...	...	19	140	108	43.8	11.5	20.5

However, when the mother's diet during pregnancy contained an excess of calcium and cod-liver oil, then the young rats showed less disorders of general nutrition and rachitic changes in the skeleton. The average figures of the weight and calcification of the skeleton of the N₁ group of rats, belonging to the litters 621, 624 and 646, and those of the N₂ group showed this quite definitely (see Table). These results emphasise the importance for the young not only of an excess of fat-soluble factor in the form of cod-liver oil, but also of ample calcium in the mother's diet during pregnancy.

It was also recorded that *at the day of birth* the Ca and P content in the young was nearly the same, irrespective of the mother's previous diet [Korenchevsky and Carr, 1923, 2]. Therefore our observations support the hypothesis, already suggested by us [1923, 1]. Our present view with regard to the influence of calcium in the mother's diet during pregnancy can be summarised as follows.

Calcium is of importance not only to the structure of the skeleton: it is a necessary component of all cells, and the nuclei contain an especially large

¹ However, when interpreting these results, it is necessary to bear in mind that butter can vary much in its fat-soluble factor content.

amount of it. On the calcium content in the tissues and environment depend the working capacity and the different excitability and permeability of blood vessels, the coagulation of the blood, the resistance to certain toxins, etc. It may, therefore, be assumed that the intake of large quantities of calcium may improve the composition and functions of the mother's organism during the complex process of pregnancy, when the production of new tissues is markedly increased and the whole metabolism is altered. It is natural to expect that a more perfect organism will produce more healthy offspring, more capable of resisting deleterious pathological factors, in particular a rickets-producing — A diet.

Probably the presence of cod-liver oil in the mother's diet during pregnancy helps to make use of the excess of calcium and favourably influences the nutrition and calcium metabolism of the young.

There are indications that feeding animals with cod-liver oil is one of the most efficient ways to increase the store of fat-soluble factor in the organism. Coward, Lush and Palmer [1923] and Goldblatt and Soames [1923] stated that the storage of growth-promoting and anti-rachitic factors in the liver of rats varies very much with the concentration of these factors in the diet. The latter authors found an increase of growth-promoting factor in the livers of those animals which were fed previously with a cod-liver oil diet as compared with those of rats fed on a butter diet.

These experiments of ours add further to the explanation, already given [Korenchevsky and Carr, 1924] with regard to the divergence of results obtained by us and by Hess and Weinstock [1924, 1]. These latter workers in their interesting investigation of the anti-rachitic effect of addition of cod-liver oil to the diet of pregnant rats used a mixed diet, which they defined "ample, although not an optimal dietary" (p. 1). Its calcium content was not estimated but seemed to be rather low. Possibly, owing to this also the results obtained by Hess and Weinstock were similar to those of ours obtained in the N_1 and D_2 groups of rats.

Here also we refer to Korenchevsky's [1922] experiments: the most severe changes of the skeleton, practically identical with rickets, were produced in young rats, which, as well as their mothers *during lactation*, were fed on a diet deficient in calcium, but containing an *ample amount of cod-liver oil*.

Hess and Weinstock [1924, 2] do not give any data with regard to the diet of the pregnant women to whom cod-liver oil was given during pregnancy with the aim of protecting their children from rickets. In their recent experiments on rats [1924, 2] cod-liver oil was not added to the diet of the pregnant animals, nor was the amount of consumed calcium determined. In their experiments the diet of the rats during pregnancy consisted of different ingredients, given separately, not in the form of a paste, which made it difficult to determine what was consumed. However, owing to the differences in experimental technique, Hess and Weinstock themselves [1924, 1, p. 6] state that "it is difficult to compare the two series of experiments" (theirs and ours). Another

statement of these authors runs as follows [1924, 2, p. 1562]: "It may be stated as a principle that the resistance to rickets can be lessened by means of inadequacy of a mother's diet far more readily than a refractory condition can be brought about." Besides the results of our experiments on the influence of maternal diet upon the young, experiments of Kennedy and Dutcher [1922], Drummond, Coward and Watson [1921], Reyher [1924] and Luce [1924] showed quite definitely the great variations in growth-promoting or anti-rachitic properties of cow's milk and milk-fat, depending on the diet of the cow. Even without considering our experiments, it seems difficult to suppose that a varying amount of anti-rachitic factor in the maternal milk does not influence the resistance of the offspring to a rickets-producing diet deficient in the above factor.

Moore [1924] after giving cod-liver oil to two pregnant women observed much superior skeletal conditions in the babies born as compared with the rachitic disorders found in their previous children.

We feel that more numerous experiments are needed concerning the protective influence that the mother's feeding during pregnancy and lactation has upon the young. But we wish to emphasise once more that for these experiments and observations it is most essential to use *an optimal diet complete in every respect and to check the amount eaten*. As far as we can say at present, the presence of cod-liver oil and of an ample amount of calcium (in correct ratio with P) in such a diet is of great value.

CONCLUSIONS.

1. When the mother's "normal" diet during pregnancy was enriched with cod-liver oil and an excess of calcium, there was a marked decrease in the disorders of general nutrition and in the rachitic changes in the skeleton, produced in the young by a diet deficient in fat-soluble factor, even when the mother was also kept on the same insufficient diet during lactation.

2. This effect was not produced when the mother's "normal" diet during pregnancy contained butter as the only source of fat-soluble factor and was enriched by an excess of calcium.

3. Our experiments indicate a difference between the capability of cod-liver oil and butter to enable the animals to utilise an excess of calcium, present in the diet of the mother rats during pregnancy. At present it is impossible to state whether this difference is of a quantitative or qualitative nature owing to the large variations of anti-rachitic factor present in milk-fat.

4. Provided that the mother-rats' diet during pregnancy is complete in every respect and that the fat-soluble factor is present in the form of cod-liver oil, an ample amount of calcium in the maternal diet is of great importance for the young, kept after weaning on the above deficient diet.

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