OBSERVATIONS ON THE ETIOLOGY OF GOITRE IN BROOK TROUT.

IV. THE EFFECT OF FEEDING WITH FRESH AND STALE LIVER.*

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This report includes (1) a brief summary of the sixth annual inventory of the state of the thyroid glands in the brook trout at the hatchery of the Blooming Grove Hunting and Fishing Club, and (2) an account of some experiments in the feeding of fresh and stale liver.

The arrangement and number of the ponds and troughs, the water supply, the strain of brook trout, and their distribution in the ponds and troughs according to age, have remained unchanged since our first observations in 1909. The crowding has gradually increased during these years, but the general external appearance of cleanliness of the ponds and troughs has not changed. Those containing the fry have always been unusually well cared for. The food, consisting of hog's liver and heart, has remained constant during the six years for all fish up to the ninth month of life, while for the past three years all fish over nine months old have been fed with hashed sea fish.

Histological examinations of the thyroids of a complete series representing specimens from all the ponds and troughs have been made yearly. The condition of the thyroid up to the time the change of food is made, *i. e.*, the ninth month of life, has not varied noticeably during these six years. All have shown marked active thyroid overgrowth, as noted in previous papers. When the food is changed to sea fish at the ninth month, the thyroid overgrowth is arrested, and the gland returns to its colloid or resting stage in about thirty-five to forty days (1). During the three years that this effect has been studied, no further hypertrophy or growth of the thyroid has been observed, although the fish remain in the ponds for a period of about two years after the change of food is instituted. On the other hand, when liver was used as the food throughout their lives in captivity, the thyroid overgrowth progressed continuously to visible external manifestations in practically all the fish by the end of the second year. The substitution of sea fish as a food has proved to be a specific curative and preventive measure under apparently the same conditions where liver as food caused continuous thyroid overgrowth.

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In previous papers (2, 3, 4) it has been suggested that the volume of water, its oxygen supply, its content of excreta (overcrowding), and the highly artificial food (liver and heart muscle) might be factors in causing the thyroid overgrowth. It was on account of the rapid regression of the thyroid overgrowth when sea fish was fed, and on account of its continuous growth when liver and heart muscle were fed, that food was more particularly suspected of playing an important part in stimulating the thyroid to this continuous growth. If this was a factor, it seemed probable that simple experiments in which the freshest liver was fed and experiments in which distinctly stale liver was fed might reveal differences in the thyroid growth. To this end the following experiments were made.

Two troughs were selected from the series of twenty-one. The fry of one were fed in the usual manner (twice daily) with the freshest liver, while the fry of the others were fed with portions of the same hashed liver as above, which had been kept in the cold chamber (11° to 15° C.) for two days. The experiments were begun on July 16 and terminated September 17, at which time the food of all fry was changed to sea fish. Two fish were taken at weekly intervals from each trough. As controls, specimens were taken from the twenty-one troughs at the beginning of the experiment, and two specimens at weekly intervals from one adjoining trough, which were fed on the general stockroom supply. At the end of the two months there were no gross changes in size, activity, or general appearance in the two sets. Histological preparations were made from all these thyroids. Study of the condition of the thyroids showed that there was a slight gradual increase in the degree of thyroid overgrowth noticeable in the second month in those fed with the freshest liver over those fed with the same liver held for two days. No difference could be distinguished between those fed with the freshest liver and the controls fed from the general supply.¹

¹ Similar experiments have been carried out on rats, where better control could be had. Thus two series of twenty-one young rats each were divided into groups of three each. The first group was fed on the fresh hog's liver, from animals killed the same day; the second group was fed with the same amount of the same liver one day old; and each subsequent group was fed with the same liver one day older than the preceding group. It was kept at room temperature screened from flies. They were fed with liver six times weekly, while bread and water were kept continuously in the cages. All gained in weight, those getting the freshest liver slightly more than those getting the staler liver. One rat in each group was killed at intervals of two weeks, and the thyroids were examined microscopically. There was distinct hypertrophy, as judged by the reduction in stainable colloid and increase in the size of thyroid cells, in those groups getting liver 1, 2, and 3 days old, while those getting fresh liver and liver 4, 5, and 6 days old had normal or nearly normal glands.

These findings were the reverse of what I thought might occur, as I had in mind the possibility that autolysis and bacterial digestion of the liver might produce substances capable of stimulating the thyroid cells to increased activity.

A plausible explanation for these findings is not at hand. The lack of control over the amounts of liver taken by the fish seemed suggestive, but experiments with rats where the quantity was controlled show in general the same results. The idea that certain products of autolysis and bacterial decomposition of the liver act as irritants to the thyroid may be abandoned. Since controlled experiments show only a very slight thyroid hypertrophy, one may conclude that the diet is only a contributing factor, and that it may act by increasing the work of the thyroid in order to maintain a general increase in metabolism, especially in connection with the overfeeding of a nutritionally incomplete diet.

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