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The influence of hunger and temperature upon the utilization of food substances.

By EDUARD UHLENHUTH.

[*From the Laboratories of the Rockefeller Institute for Medical Research.*]

In the larvæ of amphibians when the thyroid glands begin to excrete the thyroid hormone, metamorphosis of the larvæ into adult animals takes place. Since larvæ with fully developed thyroid glands frequently do not metamorphose, and since in the thyroid gland of the normal larvæ, large quantities of "colloid" are present in the follicles for a considerable time before metamorphosis, it is very probable that the thyroid gland cannot begin to excrete its hormone unless a second factor is present in the larvæ. It seems that this factor is elaborated during the process of growth and must be present in a definite quantity in order that the thyroid function may begin. This is shown in two tables in which for several series of the marbled and the tiger salamanders, the age at which metamorphosis took place and the rate of growth were recorded. The greater the rate of growth the shorter the length of the larval period. As a consequence the product of the rate of growth into the duration of the larval period gives a fairly constant value K. The maximum deviations observed can be traced back to certain causes which will be discussed immediately.

Hence it is evident that metamorphosis not only depends upon the thyroid hormone but also on a second substance, the quantity of which increases in the same ratio as growth. This second substance must be present in a certain quantity in order that metamorphosis can take place. The rate at which it is formed from the same kind of food and for the same rate of growth is distinctly influenced by two factors; by the quantity of food available to the larvæ, and by the temperature.

A series of the marbled salamanders (*A* 1916) required 186 days to metamorphose, when they grew at a rate of 0.21; K was 39. Another series (*C* 1916), which was fed the same food but kept

at a temperature lower by 10 degrees, needed at the same rate of growth 243 days to metamorphose. *K* was therefore higher than for series *A* (51). The same was true for other series of marbled as well as tiger salamanders; in all of these series the length of the larval period was increased more than the rate of growth was decreased, and consequently the product *K* increased. In short, during the same amount of growth less of the substance was produced at low temperature than at high temperature, though the same kind of food was given to all the larvæ.

If one diminishes the quantity of food instead of lowering the temperature, the rate of growth decreases as in the case of lowered temperature, and the length of the larval period increases, as is shown in the record of four series of marbled salamanders. All four series were kept at the same temperature and fed the same kind of food, but Series *D* received only one half, Series *E* only one quarter the amount of food which was given to Series *C*, and *A* received still less food. Consequently, as in lowered temperature, the rate of growth was decreased with the diminution of food, and the length of the larval period was increased. But while in lower temperature the length of the larval period was increased more than the rate of growth was decreased, hunger increased the length of the larval period less than it decreased the rate of growth, and consequently *K* decreased instead of increasing as in lowered temperature.

When the same kind of food is available to the amphibian organism, a certain substance required for metamorphosis is elaborated, at the same rate of growth, the more easily the less food there is available, and the less readily the more the temperature is lowered.