The Growth of Fish.

THE growth of the Brown Trout (*Salmo fario*) can be divided into two distinct phases: (*a*) the phase during which growth and maintenance are dependent upon the maternal yolk; (*b*) the phase during which the fish is dependent on external food.

If the eggs are incubated at a temperature of about 10° C. the first phase of growth lasts about 100 days. During this period the embryo grows at the expense of the yolk. At an early stage in development the yolk sac becomes completely cut off from the embryo and the yolk passes, in a soluble form, through the yolk sac wall and is conveyed to the embryo by means of the vitelline veins; as the yolk diminishes in amount the vitelline veins become reduced in size. At no period does any of the yolk enter the larval gut. The eggs hatch on about the 42nd day, but the process of hatching has no detectable influence upon the growth or the metabolism of the embryo.

The respiration of the embryo during the whole of the first growth phase uses up about 4 per cent. of the total yolk, leaving about 96 per cent. for conversion into the embryo. The following figures show the observed rate at which 100 grams of yolk are converted into living tissue.

Days after Fertilisation.	Wt. of Living Embryo in grams.		Observed Amount of Available Yolk.
	Observed.	Calculated.	
T.	W_t.	W_t.	Y.
35	8	7	92
40	10	10·5	90
46	17·5	17·5	82·5
50	24	25	76
52	28	28	72
55	35	35	65
60	47·5	46·5	52·5
64	56	56	44
68	64	65	36
71	73	73	27
75	77·5	80	22·5
79	83	86	17
81	88·5	87·5	11·5
82	89	89·5	11
85	92	91·5	8
89	94·5	94·5	5·5
93	96	96·5	4

During the whole of this period two obvious processes are taking place, namely, the increase in the amount of living embryo, and the decrease in the amount of the available yolk. During the first 50 days of development the rate of respiration is strictly proportional to the weight of the embryo (650 c.c. oxygen per kilo per hour), and the rate of respiration doubles itself about every seven days. The observed increment is equivalent to an increase in weight of 10·5 per cent. per day. After this, the rate of growth falls off almost to zero until the day comes when the young fish begins to feed and the second growth cycle begins.

The existence of a second growth cycle is difficult to understand if one assumes with Minot that from the very beginning of development the potential power of reproduction of living tissue is a decreasing entity. A more rational treatment of the data is to assume that the rate of growth depends not only on the amount of tissue already present at a particular instant but also on the amount of yolk available. During the very early stages of development the amount of yolk present does not vary very much, and the amount of tissue present at any time is given by the ordinary compound interest formula for a daily increment of 10·5 per cent.

$$T \log 1{\cdot}105 = \log \frac{W_t}{W_0},$$

where W_0 is the amount of tissue at the beginning of the development in 100 grams of eggs. But if the amount of growth also depends upon the amount of yolk present, then the equation becomes

$$T \log 1{\cdot}105 = \log \frac{W_t \,.\, 100}{W_0 \,.\, Y_t},$$

where Y_t is the number of grams of yolk in 100 grams of eggs at time T. Putting $W_0 = 0{\cdot}225$, the calculated values of W_t are shown in column 3 of the accompanying table.

The significance of this equation lies in the fact that there are no arbitrary constants. The only value which cannot be checked experimentally is the weight of the embryo immediately after fertilisation. If the calculated value for 100 grams of yolk be correct (namely, 0·225 gram), then the weight of living tissue in a single newly fertilised egg must be about 0·0002 gram.

It may be mentioned that the absence of data during the first month of development is due to the extreme difficulty of handling the eggs at this stage. Although the calculated and observed figures agree very closely, a correction may be necessary if it is found that the percentage of water in the embryo varies from that found in the yolk at different stages of development.

The daily percentage increment during the early stages is greatly affected by temperature, so that the absolute size of the embryo at any time during the first growth phase is determined by the amount of living tissue in the newly fertilised egg, the amount of yolk present, and by the temperature.

Data concerning the second growth phase are not at present available, but it seems quite clear that the quantity of food available plays a very important part in determining the rate of growth, so that the weight of a fish is no criterion of its age. The effect of temperature during this phase is also much less marked, which indicates, possibly, that the potential activity of the living tissue is subordinated to some factor which is not affected by temperature, *e.g.* the amount of available food. It will be of interest to see whether the relative rate of growth during this growth phase is comparable to that during yolk-sac development when the relative amount of food available for growth is the same in the two cases.

It may be noted that the above suggestions deny any real meaning to such an expression as "a decreasing coefficient of growth." The alternative view is obviously more in harmony with the phenomena of tissue culture and the healing of wounds, although it is not suggested that these things are the result of an increased food supply. They show, however, that the rate of growth of a whole organism has no obvious relationship to its potential capabilities of growth.

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Cambridge, April 17.

Formation of Waterspouts.

AN interesting observation of a waterspout is reported in the *Marine Observer* of April. The observation was made by Capt. G. Park, of s.s. *Risaldar*. To quote his words: ". . . The waterspout appeared to be semi-transparent, containing dark irregular masses or shapes. By selecting one or any