REGENERATION AND INHERITANCE.

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When a gold fish which happens to have a black band across its tail regenerates a new tail with the black band in the same position, after the latter has been removed, we may speak of this in a general way as being a case of inheritance through regeneration. In the same loose sense we may speak of the regeneration of an antenna instead of an eye, in certain crustaceans, and of the regeneration of antennae instead of legs in insects as cases of reversion.

Such cases, however, cannot be considered as hereditary phenomena *sensu strictu*, in the same sense as the term is being used to indicate a tranmission of a character from one individual to another. It is only through a comparative study of the regeneration of regenerated tissue and of that of the original old tissue by which the regenerated tissue was produced, that we may get a clue as to the transmission of characters in the regenerative process.

The great difficulty which presents itself in such a comparative study lies in the fact that while a great many animals do possess the power to regenerate an amputated portion or organ of their body, the lost organ and also the new organ regenerated in its stead do not possess the power to regenerate the whole animal when detached from the animal's body. Thus while a part of an animal's organism may become regenerated, a new animal is not produced in this process of regeneration. Even in those cases where fragments of the animal's body give rise to new animals, it is not always possible to obtain a new individual which would be formed entirely of regenerated tissue, and which would in its turn be ready to undergo an operation with subsequent regeneration.

Of all regenerating animals the fresh water oligochaet, Lumbriculus, presents probably the best opportunity for such a comparative study, since every piece of the worm, in fact any single segment, be that from the anterior or posterior halves of the worm's body, is capable of regenerating a new head as well as a new tail. And furthermore, as I found, a regenerated tail when severed from the old tissue may also regenerate a new head and thus form a little worm, if kept under favorable conditions. This little worm then is formed entirely of regenerated tissue, but for all the rest so far as anatomical structure is concerned it is identical with the parent organism.

It is to the regeneration in these little worms, themselves formed of regenerated tissue, that I directed my attention.

Two pieces of approximately equal length, one from the anterior half and another from the posterior half of Lumbriculus were left to regenerate for fourteen days. Let us name all these pieces obtained from the front and hind portions of the worm, A and B, respectively. I showed elsewhere that pieces taken from the anterior region of worms regenerate at a higher rate than those taken from more posterior regions. Thus, all the A pieces, regenerated new tails with a rate of 4.4 segments on an average to each one old segment; while the B pieces regenerated on the average 2.6 segments per one old segment. To make this matter clear I will illustrate it by an hypothetical case. Suppose that all the A pieces and all the B pieces were composed of ten old segments each, then the regenerated tails would on the average have consisted of 44 and 26 new segments, respectively.

At the end of fourteen days all the regenerated tails were cut off. A large percentage of these detached regenerated tails regenerated heads, and a new generation of worms, which presented a race of dwarfed Lumbriculi, was thus originated. We will name all these dwarfed worms **a** and **b**, the former being the descendants of the A pieces, and the latter of the B pieces.

After a while these little worms were also subjected to an amputation of their tails, and were left to regenerate for a period of fourteen days. At the end of this fortnightly period it was found that the average number of regenerated segments per one old segment was 0.11 in the **a**-worms, and 0.06 in the **b**-worms.

Measuring the power of regeneration by the average number of new segments per one old segment, we find that the power of regeneration in the A-mother pieces is greater than that in the B-mother pieces, 1.7 times, which is the ratio between 4.4 and 2.6.

According to the same principle of calculation, the power to regenerate in the little worms, **a**, which are the asexually produced offsprings of the A-mother pieces, will be 1.8 times greater than that in the little worms, **b**., which are the offspring of the B-mother pieces.

Thus we find that tissue regenerated from a part of an animal's body which possesses a high power of regeneration will also have a comparatively high power to regenerate, while tissue regenerated from a part which has a lower capacity to regenerate will also have a low capacity, and furthermore, the ratio between the rates of posterior regeneration in the mother-pieces is very nearly like that between the rates of regeneration in their regenerated offspring.

Such cases may be regarded as genuine hereditary phenomena, since a character, or the power to regenerate in this instance, is transmitted from one individual to another. It differs, however, from other cases of hereditary transmission, in the fact that the new generation is not produced from the fertilized egg by the process of embryological development, but from regenerated tissue. This led me to the conclusion that, "The property of regeneration passes over to the new tissue together with the protoplasmic material it is built of."

State University, Columbus, Ohio, November 26, 1907.