AUTHOR'S INTRODUCTION

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In the year 1868, in the second volume of his celebrated work, *"The variation of animals and plants under domestication,"* Darwin formulated the provisional hypothesis of pangenesis. The discussion of this hypothesis is preceded by a masterly survey of the phenomena to be explained. Owing to this, as well as to his clear conception of the whole problem, this part of his book has attracted universal attention. We find it mentioned in almost all works which deal with general biological questions. While, however, the general part of the chapter has until now remained the basis for all scientific considerations of the nature of heredity, the hypothesis itself has not enjoyed such general appreciation.

Darwin assumes (Variation 2: 369) that the cells, as is generally accepted, multiply by division, and that in so doing they preserve essentially the same nature. He considers that this rule forms the basis of heredity. By it, however, not all of the groups of phenomena brought together by Darwin may be explained. Especially does it not explain the effects of use and disuse, the direct action of the male element on the female, and the nature of graft-hybrids. In order to take into account these phenomena, Darwin assumes that there exists, in addition to cell division, yet another means of transfer of hereditary qualities. Each unit of the body, according to his theory,

throws off minute granules[1] which accumulate in the germ cells and buds. These granules are the bearers of the characters of the cells from which they are derived, and thus transmit those characters to the germ cells and to the buds.

Thus all the hereditary characters of the organism are represented in the egg-cells, pollen-grains, sperm-cells, and buds by minute particles. These they have received, partly by descent from former germ cells, i. e., directly, but partly by later addition from the cells and organs of the body. These minute granules are not the chemical molecules; they are much larger than these and are more correctly to be compared with the smallest known organisms. Darwin calls them gemmules (small germs).

The hypothesis of these gemmules threw an unexpected light on a series of facts which had hitherto been in absolute darkness. And if one reads attentively Darwin's discussion, he sees more and more clearly that the transmission of gemmules by cell-division, from the mother-cell to the daughter-cell, suffices to explain large groups of phenomena. Only isolated groups of facts demand in addition the hypothesis of transportation. The doctrine of latent qualities and of atavism particularly are drawn from their former darkness by Darwin's hypothesis, and his discussion of this subject (p. 357) clearly shows what great significance he imputes to this circumstance. It demands, however, only the transmission of the gemmules in cell-division, not their transportation from the growing and full-grown organs to the germ-cells.

[1]This is the term Darwin first uses. The Variation of Animals and Plants. **2**: 358. New York, 1900. *Tr.*

It has always seemed to me that most authors have not sufficiently distinguished these two aspects of the hypothesis, and that their objections against accepting the theory of transportation have misled them into overlooking the paramount significance of the doctrine of gemmules.

To my mind Darwin's provisional hypothesis of pangenesis consists of the following two propositions:

1. In every germ-cell (egg-cell, pollen-grain, bud, etc.) the individual hereditary qualities of the whole organism are represented by definite material particles. These multiply by division and are transmitted during cell-division from the mother-cell to the daughter-cells.

2. In addition, all the cells of the body, at different stages of their development, throw off such particles; these flow into the germ-cells, and transmit to them the qualities of the organism, which they are possibly lacking. (Transportation-hypothesis).

The second assumption possessed, for Darwin himself, only limited importance, in the case of plants and corals, as he considered a transportation of gemmules from one branch to another impossible. It does not apply to the workers of ants and bees, nor to the double stocks (gilliflower) mentioned several times by Darwin. These do not possess any stamens and pistils themselves, and their characteristics must therefore be transmitted from one generation to the other through the fertile single specimens of the race. The facts, for the explanation of which the theory in question was brought forth, have gained neither in number nor in trustworthiness during the twenty years since the publication of Darwin's book.

Doubts of its necessity, therefore, are quite permissible, and it is the chief service of Weismann to have

repeatedly emphasized these doubts, and to have shattered the rather generally accepted doctrine of the heredity of acquired characters.[2]

But even if, with this investigator, one rejects the second proposition, that is no reason for likewise doubting the other part of the hypothesis of pangenesis. On the contrary, it seems to me that by doing so its great significance only becomes clearer. Besides, there have been no convincing arguments brought forward against this first dogma, and no other hypothesis concerning the nature of heredity takes account of the facts in so simple and clear a manner.

Yet most authors have considered that, by refuting the transportation hypothesis, they have also refuted that of the bearers of individual hereditary characters, and they have hardly devoted any special discussion to it. In consequence of this Darwin's view has unfortunately not borne such fruit for the development of our knowledge as its originator had a full right to expect.

My problem in the following pages will be to work out the fundamental thought of pangenesis independently of the transportation hypothesis, and to connect with it the new facts which the doctrine of fertilization and the anatomy of the cell have brought to light.

I shall be guided by the thought that the physiology of heredity, and especially the facts of variation and of atavism indicate the phenomena which are to be explained, while microscopic investigation of cell-division and fertilization will teach us the morphological substratum of those processes. We shall not try to explain the mor-

[2]The designation "acquired" is not exactly well chosen. The question is: *Can characters which have originated in somatic cells* be communicated to the germ-cells. This possibility is rejected by Weismann. Compare Part II, § 5. (p. 93).

phological details of those processes; our knowledge is yet too limited for that. But, following the method of Darwin, to find in the special cases the material substratum of the physiological processes, that is our problem.

As the most important result of cell-investigation of the preceding decades, I consider the theory that all the hereditary predispositions *(Anlagen)* of the organism must be represented in the nucleus of the cell. I shall try to show that this theory leads us to assume a transportation of material particles which are bearers of the individual hereditary characters. This does not mean, however, a transportation through the whole organism, nor even from one cell to another, but one restricted to the limits of the individual cells. From the nucleus the material bearers of the hereditary characters are transported to the other organs of the protoplast. In the nucleus they are generally inactive, in the other organs of the protoplast they may become active. In the nucleus all characters are represented, in the protoplast of every cell only a limited number.

The hypothesis, therefore, becomes one of *intracellular pangenesis.* To the smallest particles, of which each represents one hereditary characteristic, I shall give a new name and call them *pangens,* because with the designation "gemmule" *(Keimchen)* is associated the idea of a transportation through the whole organism.