

## CHAPTER X.

## PANGENESIS.

**A** Provisional Hypothesis supplementing "Natural Selection."—Statement of the Hypothesis.—Difficulty as to Multitude of Gemmules.—As to Certain Modes of Reproduction.—As to Formations without the Requisite Gemmules.—Mr. Lewes and Prof. Delpino.—Difficulty as to Developmental Force of Gemmules.—As to their Spontaneous Fission.—Pangenesism and Vitalism.—Paradoxical Reality.—Pangenesism scarcely superior to Anterior Hypothesis.—Buffon.—Owen.—Herbert Spencer.—"Gemmules" as Mysterious as "Physiological Units."—Conclusion.

IN addition to the theory of "Natural Selection," by which it has been attempted to account for the origin of species, Mr. Darwin has also put forward what he modestly terms "a provisional hypothesis" (that of *Pangenesism*), by which to account for the origin of each and every individual form.

Now, though the hypothesis of Pangenesism is no necessary part of "Natural Selection," still any treatise on specific origination would be incomplete if it did not take into consideration this last speculation of Mr. Darwin. The hypothesis in question may be stated as follows: That each living organism is ultimately made up of an almost infinite number of minute particles, or organic atoms, termed "gemmules," each of which has the power of reproducing its kind. Moreover, that these particles circulate freely about the organism which is made up of them, and are derived from all the parts of all the organs of the less remote ancestors of each such organism during all the states and stages of such several ancestors' existence; and therefore of the several states of each of such ancestors' organs. That such a complete collection of gemmules is aggregated in

each ovum and spermatozoon in most animals, and each part capable of reproducing by gemmation (budding) in the lowest animals and in plants. Therefore in many of such lower organisms such a congeries of ancestral gemmules must exist in every part of their bodies, since in them every part is capable of reproducing by gemmation. Mr. Darwin must evidently admit this, since he says: "It has often been said by naturalists that each cell of a plant has the actual or potential capacity of reproducing the whole plant; but it has this power only in virtue of containing gemmules *derived from every part.*"<sup>1</sup>

Moreover, these gemmules are supposed to tend to aggregate themselves, and to reproduce in certain definite relations to other gemmules. Thus, when the foot of an eel is cut off, its reproduction is explained by Mr. Darwin as resulting from the aggregation of those floating gemmules which come next in order to those of the cut surface, and the successive aggregations of the other kinds of gemmules which come after in regular order. Also, the most ordinary processes of repair are similarly accounted for, and the successive development of similar parts and organs in creatures in which such complex evolutions occur is explained in the same way, by the independent action of separate gemmules.

In order that each living creature may be thus furnished, the number of such gemmules in each must be inconceivably great. Mr. Darwin says:<sup>2</sup> "In a highly-organized and complex animal, the gemmules thrown off from each different cell or unit throughout the body must be inconceivably numerous and minute. Each unit of each part, as it changes during development—and we know that some insects undergo at least twenty metamorphoses—must throw off its gemmules. All organic beings, moreover,

<sup>1</sup> "Animals and Plants under Domestication," vol. ii., p. 403.

<sup>2</sup> *Ibid.*, p. 366.

include many dormant gemmules derived from their grandparents and more remote progenitors, but not from all their progenitors. These *almost infinitely numerous* and minute gemmules must be included in each bud, ovule, spermatozoon, and pollen-grain." We have seen also that in certain cases, a similar multitude of gemmules must be included also in every considerable part of the whole body of each organism, but where are we to stop? There must be gemmules, not only from every organ, but from every component part of such organ, from every subdivision of such component part, and from every cell, thread, or fibre, entering into the composition of such subdivision. Moreover, not only from all these, but from each and every successive stage of the evolution and development of such successively more and more elementary parts. At the first glance this new atomic theory has charms from its apparent simplicity, but the attempt thus to follow it out into its ultimate limits and extreme consequences seems to indicate that it is at once insufficient and cumbrous.

Mr. Darwin himself is, of course, fully aware that there must be *some* limit to this aggregation of gemmules. He says: "Excessively minute and numerous as they are believed to be, an infinite number derived, during a long course of modification and descent, from each cell of each progenitor, could not be supported and nourished by the organism."

But apart from these matters, which will be more fully considered further on, the hypothesis not only does not appear to account for certain phenomena which, in order to be a valid theory, it ought to account for; but it seems absolutely to conflict with patent and notorious facts.

How, for example, does it explain the peculiar reproduction which is found to take place in certain marine worms—certain annelids?

\* "Animals and Plants under Domestication," vol. ii., p. 402.

In such creatures we see that, from time to time, one of the segments of the body gradually becomes modified till it assumes the condition of a head and this remarkable phe-



AN ANNELID DIVIDING SPONTANEOUSLY.

(A new head having been formed toward the hinder end of the body of the parent.)

nomenon is repeated again and again, the body of the worm thus multiplying serially into new individuals which successively detach themselves from the older portion. The development of such a mode of reproduction by "Natural Selection" seems not less inexplicable than does its continued performance through the aid of "pangenesis." For how can gemmules attach themselves to others to which they do not normally or generally succeed? Scarcely less

difficult to understand is the process of the stomach-carrying-off mode of metamorphosis before spoken of as existing in the Echinoderms. Next, as to certain patent and notorious facts: On the hypothesis of pangenesis, no creature can develop an organ unless it possesses the component gemmules which serve for its formation. No creature can possess such gemmules unless it inherits them from its parents, grandparents, or its less remote ancestors. Now, the Jews are remarkably scrupulous as to marriage, and rarely contract such a union with individuals not of their own race. This practice has gone on for thousands of years, and similarly also for thousands of years the rite of circumcision has been unfailingly and carefully performed. If then the hypothesis of pangenesis is well founded, that rite ought to be now absolutely or nearly superfluous from the necessarily continuous absence of certain gemmules through so many centuries and so many generations. Yet it is not at all so, and this fact seems to amount almost to an experimental demonstration that the hypothesis of pangenesis is an insufficient explanation of individual evolution.

Two exceedingly good criticisms of Mr. Darwin's hypothesis have appeared. One of these is by Mr. G. H. Lewes,<sup>4</sup> the other by Prof. Delpino of Florence.<sup>5</sup> The latter gentleman gives a report of an observation made by him upon a certain plant, which observation adds force to what has just been said about the Jewish race. He says: \* "If we examine and compare the numerous species of the genus *Salvia*, commencing with *Salvia officinalis*, which may pass as the main state of the genus, and concluding

<sup>4</sup> See *Fortnightly Review*, New Series, vol. iii., April, 1868, p. 352.

<sup>5</sup> This appeared in the *Revista Contemporanea Nazionale Italiana*, and was translated and given to the English public in *Scientific Opinion* for September 29, October 6, and October 13, 1869, pp. 365, 391, 407.

<sup>6</sup> See *Scientific Opinion*, of October 13, 1869, p. 407.

with *Salvia verticillata*, which may be taken as the most highly-developed form, and as the most distant from the type, we observe a singular phenomenon. The lower cell of each of the two fertile anthers, which is much reduced and different from the superior even in *Salvia officinalis*, is transmuted in other *salviæ* into an organ (nectarotheca) having a very different form and function, and finally disappears entirely in *Salvia verticillata*.

“Now, on one occasion, in a flower belonging to an individual of *Salvia verticillata*, and only on the left stamen, I observed a perfectly-developed and polliniferous lower cell, perfectly homologous with that which is normally developed in *Salvia officinalis*. This case of atavism is truly singular. According to the theory of Pangenesis, it is necessary to assume that all the gemmules of this anomalous formation, and therefore the mother-gemmule of the cell, and the daughter-gemmules of the special epidermic tissue, and of the very singular subjacent tissue of the endothecium, have been perpetuated, and transmitted from parent to offspring in a dormant state, and through a number of generations, such as startles the imagination, and leads it to refuse its consent to the theory of Pangenesis, however seductive it may be.” This seems a strong confirmation of what has been here advanced.

The main objection raised against Mr. Darwin's hypothesis is that it (Pangenesis) requires so many subordinate hypotheses for its support, and that some of these are not tenable.

Professor Delpino considers<sup>7</sup> that as many as eight of these subordinate hypotheses are required; namely, that—

“1. The emission of the gemmules takes place, or may take place, in all states of the cell.

<sup>7</sup> See *Scientific Opinion*, of September 29, 1869, p. 366.

"2. The quantity of gemmules emitted from every cell is very great.

"3. The minuteness of the gemmules is extreme.

"4. The gemmules possess two sorts of affinity, one of which might be called *propagative*, and the other *germinative* affinity.

"5. By means of the propagative affinity all the gemmules emitted by all the cells of the individual flow together and become condensed in the cells which compose the sexual organs, whether male or female (embryonal vesicle, cells of the embryo, pollen-grains, fovilla, antherozoids, spermatozoids), and likewise flow together and become condensed in the cells which constitute the organs of a sexual or agamic reproduction (buds, spores, bulbilli, portions of the body separated by scission, etc.).

"6. By means of the germinative affinity, every gemmule (except in cases of anomalies or monstrosities) can be developed only in cells homologous with the mother-cells of the cell from which they originated. In other words, the gemmules from any cell can only be developed in unison with the cell preceding it in due order of succession, and while in a nascent state.

"7. Of each kind of gemmule a great number perishes; a great number remains in a dormant state through many generations in the bodies of descendants; the remainder germinate and reproduce the mother-cell.

"8. Every gemmule may multiply itself by a process of scission into any number of equivalent gemmules."

Mr. Darwin has published a short notice in reply to Prof. Delpino, in *Scientific Opinion* of October 20, 1869, p. 426. In this reply he admits the justice of Prof. Delpino's attack, but objects to the alleged necessity of the first subordinate hypothesis, namely, that "the emission of gemmules takes place in all states of the cell." But if this is not the case, then a great part of the utility and dis-

inction of pangensis is destroyed; or, as Mr. Lewes justly says,\* "If gemmules produce whole cells, we have the very power which was pronounced mysterious in larger organisms."

Mr. Darwin also does not see the force of the objection to the power of self-division which must be asserted of the gemmules themselves if Pangensis be true. The objection, however, appears to many to be formidable. To admit the power of spontaneous division and multiplication in such rudimentary structures, seems a complete contradiction. The gemmules, by the hypothesis of Pangensis, are the ultimate organized components of the body, the absolute organic atoms of which each body is composed; how then *can* they be divisible? Any part of a gemmule would be an impossible (because a *less* than possible) quantity. If it is divisible into still smaller organic wholes, as a germ-cell is, it must be made up, as the germ-cell is, of subordinate component atoms, which are then the *true* gemmules. This process may be repeated *ad infinitum*, unless we get to true organic atoms, the true gemmules, whatever they may be, and they necessarily will be incapable of any process of spontaneous fission. It is remarkable that Mr. Darwin brings forward in support of gemmule fission, the observation that "Thuret has seen the zoospore of an alga divide itself, and both halves germinate." Yet on the hypothesis of Pangensis, the zoospore of an alga must contain gemmules from all the cells of the parent algæ, and from all the parts of all their less remote ancestors in all their stages of existence. What wonder then that such an excessively complex body should divide and multiply; and what parity is there between such a body and a gemmule? A steam-engine and a steel-filing might equally well be compared together.

Prof. Delpino makes a further objection which, how-

\* *Fortnightly Review*, New Series, vol. iii., April, 1868, p. 508.



ever, will only be of weight in the eyes of Vitalists. He says,\* Pangenesis is not to be received because "it leads directly to the negation of a specific vital principle, coördinating and regulating all the movements, acts, and functions of the individuals in which it is incarnated. For Pangenesis of the individual is a term without meaning. If, in contemplating an animal of high organization, we regard it purely as an aggregation of developed gemmules, although these gemmules have been evolved successively one after the other, and one within the other, notwithstanding they elude the conception of the *real and true individual*, these problematical and invisible gemmules must be regarded as so many individuals. Now, that real, true, living individuals exist in Nature, is a truth which is persistently attested to us by our consciousness. But how, then, can we explain that a great quantity of dissimilar elements, like the atoms of matter, can unite to form those perfect unities which we call individuals, if we do not suppose the existence of a specific principle, proper to the individual but foreign to the component atoms, which aggregates these said atoms, groups them into molecules, and then moulds the molecules into cells, the cells into tissues, the tissues into organs, and the organs into apparatus?"

"But, it may be urged in opposition by the Pangenesisists, your vital principle is an unknown and irresolute  $x$ . This is true; but, on the other hand, let us see whether Pangenesis produces a clearer formula, and one free from unknown elements. The existence of the gemmules is a first unknown element; the propagative affinity of the gemmules is a second; their germinative affinity is a third; their multiplication by fission is a fourth—and what an unknown element!"

"Thus, in Pangenesis, every thing proceeds by force of

\* *Scientific Opinion*, of October 13, 1869, p. 408.

unknown elements, and we may ask whether it is more logical to prefer a system which assumes a multitude of unknown elements to a system which assumes only a single one?"

Mr. Darwin appears, by "Natural Selection," to destroy the reality of species, and by Pangenesis that of the individual. Mr. Lewes observes<sup>10</sup> of the individual that "this whole is only a subjective conception which summarizes the parts, and that in point of fact it is the parts which are reproduced." But the parts are also, from the same point of view, merely subjective until we come to the absolute organic atoms. These atoms, on the other hand, are utterly invisible, intangible; indeed, in the words of Mr. Darwin, inconceivable. Thus, then, it results from the theories in question, that the organic world is reduced to utter unreality as regards all that can be perceived by the senses or distinctly imagined by the mind; while the only reality consists of the invisible, the insensible, the inconceivable. In other words, nothing is known that really is, and only the non-existent can be known. A somewhat paradoxical outcome of the speculations of those who profess to rely exclusively on the testimony of sense. "*Les extrêmes se touchent*," and extreme sensationalism shakes hands with the "das seyn ist das nichts" of Hegel.

Altogether the hypothesis of Pangenesis seems to be little, if at all, superior to anterior hypotheses of a more or less similar nature.

Apart from the atoms of Democritus, and apart also from the speculations of mediæval writers, the molecules of Bonnet and of Buffon almost anticipated the hypothesis of Pangenesis. According to the last-named author,<sup>11</sup> organic

<sup>10</sup> *Fortnightly Review*, New Series, vol. iii., April, 1868, p. 509.

<sup>11</sup> "Histoire Naturelle, générale et particulière," tome ii., 1749, p. 327. "Ces liqueurs séminales sont toutes deux un extrait de toutes les parties du corps," etc.

particles from every part of the body assemble in the sexual secretions, and by their union build up the embryo, each particle taking its due place, and occupying in the offspring a similar position to that which it occupied in the parents. In 1849, Prof. Owen, in his treatise on "Parthenogenesis," put forward another conception. According to this, the cells resulting from the subdivision of the germ-cell preserve their developmental force, unless employed in building up definite organic structures. In certain creatures, and in certain parts of other creatures, germ-cells unused are stored up, and by their agency lost limbs and other mutilations are repaired. Such unused products of the germ-cell are also supposed to become located in the generative products.

According to Mr. Herbert Spencer, in his "Principles of Biology," each living organism consists of certain so-called "physiological units." Each of these units has an innate power and capacity, by which it tends to build up and reproduce the entire organism of which it forms a part, unless in the mean time its force is exhausted by its taking part in the production of some distinct and definite tissue—a condition somewhat similar to that conceived by Prof. Owen.

Now, at first sight, Mr. Darwin's atomic theory appears to be more simple than any of the others. It has been objected that while Mr. Spencer's theory requires the assumption of an innate power and tendency in each physiological unit, Mr. Darwin's, on the other hand, requires nothing of the kind, but explains the evolution of each individual by purely mechanical conceptions. In fact, however, it is not so. Each gemmule, according to Mr. Darwin, is really the seat of powers, elective affinities, and special tendencies, as marked and mysterious as those possessed by the physiological unit of Mr. Spencer, with the single exception that the former has no tendency to build up the whole living, complex organism of which it forms a part. Some may think

this an important distinction, but it can hardly be so, for Mr. Darwin considers that his gemmule has the innate power and tendency to build up and transform itself into the whole living, complex cell of which it forms a part; and the one tendency is, in principle, fully as difficult to understand, fully as mysterious, as is the other. The difference is but one of degree, not of kind. Moreover, the one mystery in the case of the "physiological unit" explains all, while with regard to the gemmule, as we have seen, it has to be supplemented by other powers and tendencies, each distinct, and each in itself inexplicable and profoundly mysterious.

That there should be physiological units possessed of the power attributed to them, harmonizes with what has recently been put forward by Dr. H. Charlton Bastian; who maintains that under fit conditions the simplest organisms develop themselves into relatively large and complex ones. This is not supposed by him to be due to any inheritance of ancestral gemmules, but to direct growth and transformation of the most minute and the simplest organisms, which themselves, by all reason and analogy, owe their existence to immediate transformation from the inorganic world.

Thus, then, there are grave difficulties in the way of the reception of the hypothesis of Pangenesis, which, moreover, if established, would leave the evolution of individual organisms, when thoroughly analyzed, little if at all less mysterious or really explicable than it is at present.

As was said at the beginning of this chapter, "Pangenesis" and "Natural Selection" are quite separable and distinct hypotheses. The fall of one of these by no means necessarily includes that of the other. Nevertheless, Mr. Darwin has associated them closely together, and, therefore, the refutation of Pangenesis may render it advisable for those who have hitherto accepted "Natural Selection" to reconsider that theory.