two such Unions as these: our own experience of similar cases is, that there is less misery in those places in which out-door relief is checked than in those in which it is lavishly given. We believe that no information of this kind, which would command attention, can be obtained save by means of a Royal Commission; and, in face of the figures put forward in the two Blue Books which we are reviewing, it is difficult to understand how a single session can be allowed to pass without its appointment.

To compel every applicant for relief to accept the "offer of the House" or to lose all assistance, may appear a harsh measure. At first many would suffer, however easy the period of transition might be made during the process of the abolition of out-door relief; but a great gain would be made if our arguments are reliable. At least, we may claim for them the merit of simplicity We have only striven to show that Logic suggests, and History proves, that in proportion as out-door relief is great or small, the thrift, and therefore the prosperity, of the wage-earning classes are increased or diminished.

Art. III.—Pangenesis.

1. *The Variation of Animals and Plants under Domestication.* By Charles Darwin, M.A., F.R.S., &c. Murray. 1868.
2. *On the Genesis of Species.* By St. George Mivart, F.R.S. London: 1871.

THE "Provisional Hypothesis of Pangenesis" has stirred up much discussion since it was first proposed by Mr. Darwin; but neither the propositions in which it consists, nor its merits, nor even its defects, have been correctly appreciated. The following remarks are intended to supply the omissions of its critics, and to point out a path by which the suggestions of the hypothesis may be carried a stage further towards elucidation and proof.

It is necessary first to state the propositions in which the hypothesis consists. They may conveniently be arranged under three heads, according to three principal divisions of the hypothesis itself, suggested by an obvious threefold division in the phenomena which it is designed to explain. The three heads are as follows:—(1) The doctrine of gemmules; (2) The laws of generative conception and orderly growth; (3) The laws of voluntary modification.

(I.) The doctrine of gemmules is suggested by the fact, that our physiological activities in the gross are generally admitted

to have been traced to the activities of certain ultimate physiological molecules styled "cells;" so that the sum of the bodily activity is determined by the sum of the activities of the body's cells. If the cells be given, then also the body with its functions is given; whence it follows that a corporeal correspondence between descendants and ancestors suggests a connexion between the separate cells in their respective bodies. Such a postulated connexion between one cell (in the ancestor) and another cell (in the descendant) is supposed to be established by means of a minute physiological entity styled a "gemmule;" having somewhat the same relation to the cell which it represents as is borne by a seed to the parent plant. The conditions under which this connexion is supposed to be secured may be summed up in the following propositions:—

1. Gemmules are thrown off by every cell in the body; perhaps at every stage of the cell's growth, certainly at every stage of the body's growth;

2. Any one of which, when nourished under the fitting conditions, will reproduce the cell from which it sprang;

3. These circulate freely through the body itself;

4. And are so small,

5. And so numerous, that gemmules from every cell which has existed at any time in any part of the body during its whole life, not only may be, but almost certainly will be, collected together in every spermatozoon and in every ovule. Moreover, by reason of the ubiquity and number of the gemmules, this collection will not consist only of gemmules due to the actual *producer* of the spermatozoon or ovule: there will also be present gemmules derived from his or her parents, grandparents, and remoter ancestors; but the more remote the ancestor, the fewer, in general, are the gemmules directly derived from him.

Gemmules of all sorts are (probably) present everywhere in the body; but

6. They are specially determined to the generative organs, where they are perhaps modified, certainly arranged in definite and complex relations, by the operation of definite laws of the organic structure. This last statement covertly contains an indefinite number of propositions which, in the present state of our knowledge, cannot be reduced to exact terms. The same inevitable indefinitiveness is also conspicuous in the statement of the second head, the laws of generative conception and orderly growth; to which we proceed.

(II.) We are now to imagine the ovule to have been fertilized by the spermatozoon. The consequent processes are somewhat as follows. Only *ante-fetal* gemmules—gemmules, that is, thrown off by parents and ancestors when they themselves were in the

same ante-fetal state—are available for the purpose. But there is present an immense number of these, derived from ancestors of various degrees in remoteness. Some process of selection is performed, either by the fecundated ovum, or by the enveloping organism, or by both together, whereby some of the ante-fetal gemmules are picked out and preferred as the material to form the fetal germ. This first act of selection is of incalculable importance; for its effects upon the offspring will extend (probably) to the last moment of life. The germ having been formed by the apt agglomeration of gemmules, these are developed into cells. Thereupon, more gemmules are required, taken from among those which date from the corresponding ancestral state;* of which, again, an immense number, from various ancestors, are present. The above described process of selection is performed again. The elected gemmules are attached to the fetal-germ, which grows by their being developed from gemmules into cells. More gemmules are then selected and attached; and so the process is continued, until we come to the time of birth.

Owing to the imperfection of the language at our command, we are forced to describe the above process, which is probably (or certainly) continuous, under the image of a series of discrete stages. The reader must make the same kind of correction as is made in mathematics, when the limiting polygon becomes a curve or the limiting polyhedron a surface. This process of selection from among gemmules seems to decrease in importance as it proceeds further; for then the power of selection is in great part (finally altogether) performed by the cells which have been previously selected; so that the results of the earlier acts of selection exercise a powerful influence upon the results of the later, and are therefore in some sense more important.

The laws of orderly growth will be only an extension of some of the laws by which the fetus grows before birth. The difference between the two cases lies in this, that in the infant a complete set of cells has been got together, which has now only to *grow*, whereas in the fetus two processes, *growth* and *formation*, go on together.

The growth and preservation of the body is known to be effected by the continual substitution of new cells in the place of those which are continually decomposed and excreted. This process is thus explained by the hypothesis. Each cell, before

* That is, which were thrown off by the ancestral cells, when these were only the germ of a fetus. The *date* of a gemmule is the same as the date of the cell from which it sprang; and the cells which the gemmules form are of the same date as themselves. For example, gemmules thrown off by an infant at the stage of dentition, can only be used to form cells in the infant's descendants at or about the time when they shall be cutting their teeth.

its decease and excretion, provides for itself a successor, selected from the attendant gemmules (1) of *the date next in order to its own date,* (2) springing from a corresponding cell in the body of some ancestor, whether near or remote. We are ignorant of the laws which govern that selection by which one gemmule is preferred to its competitors of the same date; but it is natural to speak of a *struggle for development* among the gemmules, analogous to the struggle for life among the members of a tribe or species.

Since gemmules can become candidates for development only at the same stage of the body's growth as that at which they were produced, it follows that when a gemmule has once been passed by, so that its appropriate stage has been left behind, it is condemned to organic torpor so long as it shall continue to inhabit the body of its present possessor. Torpid or dormant gemmules perhaps propagate themselves, by fission or otherwise, the *date* of their progeny remaining unaltered.

The facts to which the hypothesis appeals under this head, are briefly as follows:—

(1.) The various organs generally increase together by orderly development, each keeping its own form and function, and not suffering transmutation into any other.

(2.) Some organs, or characteristics, which regularly differ at different stages of life, may at a later stage exhibit an ancestral resemblance which was not apparent at an earlier stage.

(3.) Variations in organs, which are not regular but abnormal, exhibit the same phenomenon. As, for example, when there is hereditary tendency to disease which does not manifest itself in infancy. In short, we thus explain by the hypothesis all those phenomena which may be styled epochal or periodic, whether normal or abnormal. The beard sprouts at the age of puberty, because the beards of our ancestors during numberless generations have sprouted at that age; from the cells of whose chins, at that same age, were derived the gemmules which formed the cells of our chins at that age. This is an example of a normal epochal phenomenon. Examples of the other classes will easily suggest themselves.

(III.) There is another class of facts, peculiar to voluntary life, which the hypothesis is also to explain. These refer to the effect, upon descendants, of acquired habits in the ancestor. "How can the use or disuse of a particular limb or of the brain affect a small aggregate of reproductive cells, seated in a distant part of the body, in such a manner that the being developed from these cells inherits the characters of either one or both parents?" (*Animals and Plants under Domestication,* vol. ii.

p. 372.) The propositions hitherto stated will explain only the body's vegetable growth. In order to state the new propositions which are suggested by Mr. Darwin's question, we should need a much more accurate and particular knowledge of the organic effect of a confirmed habit upon the cerebral structure, than is at present within our reach. Some of the kinds of cerebral change which can be imagined as possible, would suit the hypothesis better than others. If, for example, the change should extend only to the number or arrangement of the cerebral cells, and not to the internal structure of the cells themselves, then the gemmules produced by the changed brain would differ only in number, not also in constitution, from those produced before the change. This merely numerical change would not fit in with the hypothesis so obviously as a structural change.

The defects of this hypothesis have been sharply canvassed under the stimulus of a theological bias. A preliminary bias of this sort does not always rob a man of candour; but it is incompatible with the simple desire to investigate the relevant facts, because it carries with it the duty of denying sundry statements before the truth has been investigated. Therefore, it is apt also to carry with it an attitude of hostility towards a novel hypothesis, no matter how cautiously its advocates may guard their advocacy: a hostile attitude which shows itself chiefly in the magnifying of defects, but partly also in the omission to credit the hypothesis with the philosophical merit, in this case very great, to which it is entitled.

Mr. Darwin was led to suggest the hypothesis, by the feeling that some hypothesis was needed to sum up and present in a small compass those relevant facts of which he has an unrivalled knowledge. That his attempt was a tentative effort, he has himself stated. But something less than justice has been done to the hypothesis by those who have found in it nothing more than may be found in Democritus, Hippocrates, Epicurus, or Lucretius. The sentences which have been, or (with the help of a little more learning in the critics) might be, quoted from the above-mentioned authors, are as much beside the point as if they had been written by the calculating machine in the Island of Laputa.

The defects of the hypothesis are divisible into two classes; namely, formal defect and material error. The former may be supplied by experiment and observation; the latter will need to be corrected, and will entail some modification of the hypothesis such as will bring it into harmony with those facts with which in its present shape it is at variance.

The formal defects of the hypothesis are summed up by saying, that it postulates not only hypothetical *facts*, such as the exis-

tence of gemmules which have not yet been observed, but also hypothetical *links of cause and effect*, such as the physiological properties of the gemmules; and that it postulates not only *some* of these links, but *all* of them. Without entering into the common verbal disputes about the meaning of the terms "hypothesis" and "explanation," we may safely say that a hypothesis of this kind is not to be called an explanation of the facts to which it appeals. It is a brief and most ingenious summing up of those facts; it probably is a necessary preliminary to the discovery of a true explanation; and it certainly is a most useful instrument to suggest lines of investigation which cannot fail to be fruitful of valuable results; but at present the hypothesis does not explain the facts: it only sums them up by an appropriate synthesis. Consider a parallel case, which is an example of a true explanation. The observed retardation of the exterior occultation of Jupiter's satellites was hypothetically explained, before the motion of light had been ascertained, by supposing that light travels with a finite velocity; but we had not also to *suppose* that, this being so, light would arrive the later at a given spot in proportion to the remoteness of its starting point. At present, the hypothesis of pangenesis both supposes that the gemmules exist, and also that they perform the functions assigned to them.

In order to supply the defect suggested by this criticism, we need either a microscopic observation of small bodies existing under such conditions that they may be plausibly identified with the gemmules; or else a chemistry and mechanology of gemmules analogous to the common chemistry and mechanics, such as might be plausibly deduced from a wide observation and comparison of physiological analogies. If these conditions should ever be fulfilled, the hypothesis would become a well grounded theory: if the deduction should be afterwards made not only plausible but scientifically rigorous, the theory would become a demonstrated truth. Mr. Darwin is well aware of the defect, and he himself has done something to supply it. At p. 380 of the volume quoted above, he assigns some deeply interesting analogies in support of "the assumed elective affinity [of a gemmule] for that particular cell which precedes it in the order o development." There is no need to wonder that so novel an inquiry has not yet been wholly exhausted.

The conspicuous candour of Mr. Darwin is shown by the prominence which he has given to a weak point, when he says, "Parthenogenesis is no longer wonderful; in fact, the wonder is, that it should not oftener occur." (*Ib.*, p. 383.) Its facile explanation of parthenogenesis is no advantage to the hypothesis. We should rather expect, if the hypothesis be true, that parthenogenesis would be the common rule, occurring every day and in all

classes of animals, instead of being, as it is, the exception and wholly confined to organisms very low in the scale. This objection is by no means fatal to the hypothesis as a whole; but it is an objection, not a support; and it serves to mark the transition from the formal defect to the material error.

Material error in a hypothesis lies in its contradicting known matter of fact. The contradiction in the present case is summed up by Mr. St. George Mivart in the following passage:—

"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 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 absolutely or nearly superfluous from the necessarily continuous absence of certain gemmules through so many centuries and so many generations."—*The Genesis of Species*, p. 212. "Yet," he adds, "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."

These remarks have undoubtedly great weight; but perhaps Mr. Mivart ought (both here and elsewhere) to have kept in view more closely the fact, that no one has asserted the perfect sufficiency of the hypothesis.

The same objection might easily be stated in a more general, not to say a better, form. Under the hypothesis in its present shape, the attainment of a given age, suppose a hundred years, by a given individual, would imply that at least one of his ancestors had attained to that age; and again, a still more remote ancestor would be needed to explain that one; and so on for ever, until we come to the origin of life. This is not easily compatible with the general hypothesis of evolution; for it is difficult and contrary to existing analogy, to assert the primitive type or types to have been immensely long-lived.

But these objections are not fatal. They might even in a certain sense be met at once by assigning further hypothetical powers or functions to the gemmules; but to do this would be, in the present state of our knowledge, only to employ our ingenuity in the dark. We rather hope to see the hypothesis at the same time interpreted, corrected, and established, by a course of fruitful investigation such as Mr. Darwin has already begun.

We trust that no disrespect is implied in thus freely criticising the work of a man who stands at the head of modern science:

Ἀνδρὸς ὃν οὐδ' αἰνεῖν τοῖσι κακοῖσι θέμις.

We submit the foregoing remarks to his judgment, for castigation or approval, if he shall think them worthy to be honoured by his attention.