ART. III. — 1. *Contributions to the Theory of Natural Selection.* By ALFRED RUSSEL WALLACE. London and New York: Macmillan & Co. 1870. 8vo. pp. 384.

2. *On the Genesis of Species.* By ST. GEORGE MIVART, F. R. S. London and New York: Macmillan & Co. 1871. 8vo. pp. 314.

3. *The Descent of Man, and Selection in Relation to Sex.* By CHARLES DARWIN, M. A., F. R. S., etc. In two volumes. New York: D. Appleton & Co. 1871. 8vo. pp. 409 and 436.

4. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life.* By CHARLES DARWIN, M. A., F. R. S., etc. Fifth Edition, with Additions and Corrections. New York: D. Appleton & Co. 1871. 8vo. pp. 447.

IT is now nearly twelve years since the discussion of that "mystery of mysteries," the origin of species, was reopened by the publication of the first edition of Mr. Darwin's most remarkable work. Again and again in the history of scientific debate this question had been discussed, and, after exciting a short-lived interest, had been condemned by cautious and conservative thinkers to the limbo of insoluble problems or to the realm of religious mystery. They had, therefore, sufficient grounds, *a priori*, for anticipating that a similar fate would attend this new revival of the question, and that, in a few years, no more would be heard of the matter; that the same condemnation awaited this movement which had overwhelmed the venturesome speculations of Lamarck and of the author of the "Vestiges of Creation." This not unnatural anticipation has been, however, most signally disappointed. Every year has increased the interest felt in the question, and at the present moment the list of publications which we place at the head of this article testifies to the firm hold which the subject has acquired in this short period on the speculative interests of all inquisitive minds. But what can we say has really been accomplished by this debate; and what reasons have we for believing that the judgment of conservative thinkers will not,

in the main, be proved right after all, though present indications are against them? One permanent consequence, at least, will remain, in the great additions to our knowledge of natural history, and of general physiology, or theoretical biology, which the discussion has produced; though the greater part of this positive contribution to science is still to be credited directly to Mr. Darwin's works, and even to his original researches. But, besides this, an advantage has been gained which cannot be too highly estimated. Orthodoxy has been won over to the doctrine of evolution. In asserting this result, however, we are obliged to make what will appear to many persons important qualifications and explanations. We do not mean that the heads of leading religious bodies, even in the most enlightened communities, are yet willing to withdraw the dogma that the origin of species is a special religious mystery, or even to assent to the hypothesis of evolution as a legitimate question for scientific inquiry. We mean only, that many eminent students of science, who claim to be orthodox, and who are certainly actuated as much by a spirit of reverence as by scientific inquisitiveness, have found means of reconciling the general doctrine of evolution with the dogmas they regard as essential to religion. Even to those whose interest in the question is mainly scientific this result is a welcome one, as opening the way for a freer discussion of subordinate questions, less trammelled by the religious prejudices which have so often been serious obstacles to the progress of scientific researches.

But again, in congratulating ourselves on this result, we are obliged to limit it to the doctrine of evolution in its most general form, the theory common to Lamarck's zoölogical philosophy, to the views of the author of the "Vestiges of Creation," to the general conclusions of Mr. Darwin's and Mr. Wallace's theory of Natural Selection, to Mr. Spencer's general doctrine of evolution, and to a number of minor explanations of the processes by which races of animals and plants have been derived by descent from different ancestral forms. What is no longer regarded with suspicion as secretly hostile to religious beliefs by many truly religious thinkers is that which is denoted in common by the various names "transmutation," "development," "derivation," "evolution," and "descent with modifi-

cation." These terms are synonymous in their primary and general signification, but refer secondarily to various hypotheses of the processes of derivation. But there is a choice among them on historical grounds, and with reference to associations, which are of some importance from a theological point of view. "Transmutation" and "development" are under ban. "Derivation" is, perhaps, the most innocent word; though "evolution" will probably prevail, since, spite of its etymological implication, it has lately become most acceptable, not only to the theological critics of the theory, but to its scientific advocates; although, from the neutral ground of experimental science, "descent with modification" is the most pertinent and least exceptionable name.

While the general doctrine of evolution has thus been successfully redeemed from theological condemnation, this is not yet true of the subordinate hypothesis of Natural Selection, to the partial success of which this change of opinion is, in great measure, due. It is, at first sight, a paradox that the views most peculiar to the eminent naturalist, whose work has been chiefly instrumental in effecting this change of opinion, should still be rejected or regarded with suspicion by those who have nevertheless been led by him to adopt the general hypothesis, — an hypothesis which his explanations have done so much to render credible. It would seem, at first sight, that Mr. Darwin has won a victory, not for himself, but for Lamarck. Transmutation, it would seem, has been accepted, but Natural Selection, its explanation, is still rejected by many converts to the general theory, both on religious and scientific grounds. But too much weight might easily be attributed to the deductive or explanatory part of the evidence, on which the doctrine of evolution has come to rest. In the half-century preceding the publication of the "Origin of Species," inductive evidence on the subject has accumulated, greatly outweighing all that was previously known; and the "Origin of Species" is not less remarkable as a compend and discussion of this evidence than for the ingenuity of its explanations. It is not, therefore, to what is now known as "Darwinism" that the prevalence of the doctrine of evolution is to be attributed, or only indirectly. Still, most of this effect is due to Mr. Darwin's work, and some-

thing undoubtedly to the indirect influence of reasonings that are regarded with distrust by those who accept their conclusions; for opinions are contagious, even where their reasons are resisted.

The most effective general criticism of the theory of Natural Selection which has yet appeared, or one which, at least, is likely to exert the greatest influence in overcoming the remaining prejudice against the general doctrine of evolution, is the work of Mr. St. George Mivart "On the Genesis of Species." Though, as we shall show in the course of this article, the work falls far short of what we might have expected from an author of Mr. Mivart's attainments as a naturalist, yet his position before the religious world, and his unquestionable familiarity with the theological bearings of his subject, will undoubtedly gain for him and for the doctrine of evolution a hearing and a credit, which the mere student of science might be denied. His work is mainly a critique of "Darwinism"; that is, of the theories peculiar to Mr. Darwin and the "Darwinians," as distinguished from the believers in the general doctrine of evolution which our author accepts. He also puts forward an hypothesis in opposition to Mr. Darwin's doctrine of the predominant influence of Natural Selection in the generation of organic species, and their relation to the conditions of their existence. On this hypothesis, called "Specific Genesis," an organism, though at any one time a fixed and determinate species, approximately adapted to surrounding conditions of existence, is potentially, and by innate potential combinations of organs and faculties, adapted to many other conditions of existence. It passes, according to the hypothesis, from one form to another of specific "manifestation," abruptly and discontinuously in conformity to the emergencies of its outward life; but in any condition to which it is tolerably adapted it retains a stable form, subject to variation only within determinate limits, like oscillations in a stable equilibrium. For this conception our author is indebted to Mr. Galton, who, in his work on "Hereditary Genius," "compares the development of species with a many-faceted spheroid tumbling over from one facet or stable equilibrium to another. The existence of internal conditions in animals," Mr. Mivart adds (p. 111), "corresponding with such facets is

denied by pure Darwinians, but it is contended in this work that something may also be said for their existence." There are many facts of variation, numerous cases of abrupt changes in individuals both of natural and domesticated species, which, of course, no Darwinian or physiologist denies, and of which Natural Selection professes to offer no direct explanation. The causes of these phenomena, and their relations to external conditions of existence, are matters quite independent of the principle of Natural Selection, except so far as they may directly affect the animal's or plant's well-being, with the origin of which this principle is alone concerned. General physiology has classified some of these sudden variations under such names as "reversion" and "atavism," or returns more or less complete to ancestral forms. Others have been connected together under the law of "correlated or concomitant variations," changes that, when they take place, though not known to be physically dependent on each other, yet usually or often occur together. Some cases of this law have been referred to the higher, more fundamental laws of homological variations, or variations occurring together on account of the relationships of homology, or due to similarities and physical relations between parts of organisms, in tissues, organic connections, and modes of growth. Other variations are explained by the laws and causes that determine monstrous growths. Others again are quite inexplicable as yet, or cannot yet be referred to any general law or any known antecedents. These comprise, indeed, the most common cases. The almost universal prevalence of well-marked phenomena of variation in species, the absolutely universal fact that no two individual organisms are exactly alike, and that the description of a species is necessarily abstract and in many respects by means of averages, — these facts have received no particular explanations, and might indeed be taken as ultimate facts or highest laws in themselves, were it not that in biological speculations such an assumption would be likely to be misunderstood, as denying the existence of any real determining causes and more ultimate laws, as well as denying any known antecedents or regularities in such phenomena. No physical naturalist would for a moment be liable to such a misunderstanding, but would, on the contrary, be more likely to be off

his guard against the possibility of it in minds otherwise trained and habituated to a different kind of studies. Mr. Darwin has undoubtedly erred in this respect. He has not in his works repeated with sufficient frequency his faith in the universality of the law of causation, in the phenomena of general physiology or theoretical biology, as well as in all the rest of physical nature. He has not said often enough, it would appear, that in referring any effect to "accident," he only means that its causes are like particular phases of the weather, or like innumerable phenomena in the concrete course of nature generally, which are quite beyond the power of finite minds to anticipate or to account for in detail, though none the less really determinate or due to regular causes. That he has committed this error appears from the fact that his critic, Mr. Mivart, has made the mistake, which nullifies nearly the whole of his criticism, of supposing that "the theory of Natural Selection may (though it need not) be taken in such a way as to lead men to regard the present organic world as formed, so to speak, *accidentally*, beautiful and wonderful as is confessedly the hap-hazard result" (p. 33). Mr. Mivart, like many another writer, seems to forget the age of the world in which he lives and for which he writes, — the age of "experimental philosophy," the very stand-point of which, its fundamental assumption, is the universality of physical causation. This is so familiar to minds bred in physical studies, that they rarely imagine that they may be mistaken for disciples of Democritus, or for believers in "the fortuitous concourse of atoms," in the sense, at least, which theology has attached to this phrase. If they assent to the truth that may have been meant by the phrase, they would not for a moment suppose that the atoms move fortuitously, but only that their conjunctions, constituting the actual concrete orders of events, could not be anticipated except by a knowledge of the natures and regular histories of each and all of them, — such knowledge as belongs only to omniscience. The very hope of experimental philosophy, its expectation of constructing the sciences into a true philosophy of nature, is based on the induction, or, if you please, the *a priori* presumption, that physical causation is universal; that the constitution of nature is written in its actual manifestations,

and needs only to be deciphered by experimental and inductive research; that it is not a latent invisible writing, to be brought out by the magic of mental anticipation or metaphysical meditation. Or, as Bacon said, it is not by the "anticipations of the mind," but by the "interpretation of nature," that natural philosophy is to be constituted; and this is to presume that the order of nature is decipherable, or that causation is everywhere either manifest or hidden, but never absent.

Mr. Mivart does not wholly reject the process of Natural Selection, or disallow it as a real cause in nature, but he reduces it to "a subordinate rôle" in his view of the derivation of species. It serves to perfect the imperfect adaptations and to meet within certain limits unfavorable changes in the conditions of existence. The "accidents" which Natural Selection acts upon are allowed to serve in a subordinate capacity and in subjection to a foreordained, particular, divine order, or to act like other agencies dependent on an evil principle, which are compelled to turn evil into good. Indeed, the only difference on purely scientific grounds, and irrespective of theological considerations, between Mr. Mivart's views and Mr. Darwin's is in regard to the *extent* to which the process of Natural Selection has been effective in the modifications of species. Mr. Darwin himself, from the very nature of the process, has never supposed for it, as a cause, any other than a co-ordinate place among other causes of change, though he attributes to it a superintendent, directive, and controlling agency among them. The student of the theory would gather quite a different impression of the theory from Mr. Mivart's account of it, which attributes to "Darwinians" the absurd conception of this cause as acting "alone" to produce the changes and stabilities of species; whereas, from the very nature of the process, other causes of change, whether of a known or as yet unknown nature, are presupposed by it. Even Mr. Galton's and our author's hypothetical "facets," or internal conditions of abrupt changes and successions of stable equilibriums, might be among these causes, if there were any good inductive grounds for supposing their existence. Reversional and correlated variations are, indeed, due to such internal conditions and to laws of inheritance, which have been ascertained inductively as at least laws of

phenomena, but of which the causes, or the antecedent conditions in the organism, are unknown. Mr. Darwin continually refers to variations as arising from unknown causes, but these are always such, so far as observation can determine their relations to the organism's conditions of existence, that they are far from accounting for, or bearing any relations to, the adaptive characters of the organism. It is solely upon and with reference to such adaptive characters that the process of Natural Selection has any agency, or could be supposed to be effective. If Mr. Mivart had cited anywhere in his book, as he has not, even a single instance of sudden variation in a whole race, either in a state of nature or under domestication, which is not referable by known physiological laws to the past history of the race on the theory of evolution, and had further shown that such a variation was an adaptive one, he might have weakened the arguments for the agency and extent of the process of Natural Selection. As it is, he has left them quite intact.

The only direct proofs which he adduces for his theory that adaptive as well as other combinations proceed from innate predeterminations wholly within the organism, are drawn from, or rather assumed in, a supposed analogy of the specific forms in organisms to those of crystals. As under different circumstances or in different media the same chemical substances or constituent substances assume different and distinct crystalline forms, so, he supposes, organisms are distinct manifestations of typical forms, one after another of which will appear under various external conditions. He quotes from Mr. J. J. Murphy, "Habit and Intelligence," that, "it needs no proof that in the case of spheres and crystals, the forms and structures are the effect and not the cause of the formative principle. Attraction, whether gravitative or capillary, produces the spherical form; the spherical form does not produce attraction. And crystalline polarities produce crystalline structure and form; crystalline structure and form do not produce polarities." And, by analogy, Mr. Murphy and our author infer that innate vital forces always produce specific vital forms, and that the vital forms themselves, or "accidental" variations of them, cannot modify the types of action in vital force. Now, although Mr. Murphy's propositions may need no proof, they

will bear correction; and, clear as they appear to be, a better interpretation of the physical facts is needed for the purposes of tracing out analogy and avoiding paralogism. Strange as it may seem, Mr. Murphy's clear antitheses are not even partially true. No abstraction ever produced any other abstraction, much less a concrete thing. The abstract laws of attraction never produced any body, spherical or polyhedral. It was actual forces acting in definite ways that made the sphere or crystal; and the sizes, particular shapes, and positions of these bodies determined in part the action of these actual forces. It is the resultants of many actual attractions, dependent in turn on the actual products, that determine the spherical or crystalline forms. Moreover, in the case of crystals, neither these forces nor the abstract law of their action in producing definite angles reside in the finished bodies, but in the properties of the surrounding media, portions of whose constituents are changed into crystals, according to these properties and to other conditioning circumstances. So far as these bodies have any innate principle in them concerned in their own production, it is manifested in determining, not their general agreements, but their particular differences in sizes, shapes, and positions. The particular position of a crystal that grows from some fixed base or nucleus, and the particular directions of its faces, may, perhaps, be said to be *innate;* that is, they were determined at the beginning of the particular crystal's growth. Finding, therefore, what Mr. Murphy and Mr. Mivart suppose to be innate to be really in the outward conditions of the crystal's growth, and what they would suppose to be superinduced to be all that is innate in it, we have really found the contrast in place of an analogy between a crystal and an organism. For, in organisms, no doubt, and as we may be readily convinced without resort to analogy, there is a great deal that is really innate, or dependent on actions in the organism, which diversities of external conditions modify very little, or affect at least in a very indeterminate manner, so far as observation has yet ascertained. External conditions are, nevertheless, essential factors in development, as well as in mere increase or growth. No animal or plant is developed, nor do its developments acquire any growth without very special external condi-

tions. These are quite as essential to the production of an organism as a crystalline nucleus and fluid material are to the growth and particular form of a crystal; and as the general resemblances of the crystals of any species, the agreements in their angles, are results of the physical properties of their food and other surrounding conditions of their growth, so the general resemblances of animals or plants of any species, their agreements in specific characters, are doubtless due, in the main, to the properties of what is innate in them, yet not to any abstraction. This is sufficiently conspicuous not to "need any proof," and is denied by no Darwinian. The analogy is so close indeed between the internal determinations of growth in an organism and the external ones of crystals, that Mr. Darwin was led by it to invent his "provisional hypothesis of Pangenesis," or theory of gemmular reproduction. The gemmules in this theory being the perfect analogues of the hypothetical atoms of the chemical substances that are supposed to arrange themselves in crystalline forms, the theory rather gives probability to the chemical theory of atoms than borrows any from it. But we shall recur to this theory of Pangenesis further on.

General physiology, or physical and theoretical biology, are sciences in which, through the study of the laws of inheritance, and the direct and indirect effect of external conditions, we must arrive, if in any way, at a more and more definite knowledge of the causes of specific manifestations; and this is what Mr. Darwin's labors have undertaken to do, and have partially accomplished. Every step he has taken has been in strict conformity to the principles of method which the examples of inductive and experimental science have established. A stricter observance of these by Mr. Murphy and our author might have saved them from the mistake we have noticed, and from many others, — the "realism" of ascribing efficacy to an abstraction, making attraction and polarity produce structures and forms independently of the products and of the concrete matters and forces in them. A similar "realism" vitiates nearly all speculations in theoretical biology, which are not designedly, or even instinctively, as in Mr. Darwin's work, made to conform to the rigorous rules of experimental philosophy. These require us to assume no causes that are not true or phenomenally known,

and known in some other way than in the effect to be explained; and to prove the sufficiency of those we do assume in some other way than by putting an abstract name or description of an effect for its cause, like using the words "attraction" and "polarity" to account for things the matters of which have *come together* in a *definite form*. It may seem strange to many readers to be told that Mr. Darwin, the most consummate speculative genius of our times, is no more a maker of hypotheses than Newton was, who, unable to discover the cause of the properties of gravitation, wrote the often-quoted but much misunderstood words, "*Hypotheses non fingo*." "For," he adds, "whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction. Thus it was that the impenetrability, the mobility, and the impulsive force of bodies, and the laws of motion and gravitation, were discovered. And to us it is enough that gravity does really exist and act according to the laws which we have explained, and abundantly serves to account for all the motions of the celestial bodies and of our sea." Thus, also, it is that the variability of organisms and the known laws of variation and inheritance, and of the influences of external conditions, and the law of Natural Selection, have been discovered. And though it is not enough that variability and selection do really exist and act according to laws which Mr. Darwin has explained (since the limits of their action and efficiency are still to be ascertained), yet it is enough for the present that Darwinians do not rest, like their opponents, contented with framing what Newton would have called, if he had lived after Kant, "*transcendental hypotheses*," which have no place in experimental philosophy. It may be said that Mr. Darwin has invented the hypothesis of Pangenesis, against the rules of this philosophy; but so also did Newton invent the corpuscular theory of light, with a similar purpose and utility.

In determining the limits of the action of Natural Selection, and its sufficiency within these limits, the same demonstrative adequacy should not, for obvious reasons, be demanded as con-

ditions of assenting to its highly probable truth, that Newton proved for his speculation. For the facts for this investigation are hopelessly wanting. Astronomy presents the anomaly, among the physical sciences, of being the only science that deals in the concrete with a few naturally isolated causes, which are separated from all other lines of causation in a way that in other physical sciences can only be imitated in the carefully guarded experiments of physical and chemical laboratories. The study of animals and plants under domestication is, indeed, a similar mode of isolating with a view to ascertaining the physical laws of life by inductive investigations. But the theory of Natural Selection, in its actual application to the phenomena of life and the origin of species, should not be compared to the theory of gravitation in astronomy, nor to the principles of physical science as they appear in the natures that are shut in by the experimental resources of the laboratory, but rather to these principles as they are actually working, and have been working, in the concrete courses of outward nature, in meteorology and physical geology. Still better, perhaps, at least for the purposes of illustration, we may compare the principle of Natural Selection to the fundamental laws of political economy, demonstrated and actually at work in the production of the values and the prices in the market of the wealth which human needs and efforts demand and supply. Who can tell from these principles what the market will be next week, or account for its prices of last week, even by the most ingenious use of hypotheses to supply the missing evidence? The empirical economist and statistician imagines that he can discover some other principles at work, some predetermined regularity in the market, some "innate" principles in it, to which the general laws of political economy are subordinated; and speculating on them, might risk his own wealth in trade, as the speculative "vitalist" might, if anything could be staked on a transcendental hypothesis. In the same way the empirical weather-philosopher thinks he can discern regularities in the weather, which the known principles of mechanical and chemical physics will not account for, and to which they are subordinate. This arises chiefly from his want of imagination, of a clear mental grasp of these principles, and of an adequate knowledge of the resources of legitimate hypoth

esis to supply the place of the unknown incidental causes through which these principles act. Such are also the sources of most of the difficulties which our author has found in the applications of the theory of Natural Selection.

His work is chiefly taken up with these difficulties. He does not so much insist on the probability of his own transcendental hypothesis, as endeavor to make way for it by discrediting the sufficiency of its rival; as if this could serve his purpose; as if experimental philosophy itself, without aid from "Darwinism," would not reject his metaphysical, occult, transcendental hypothesis of a specially predetermined and absolute fixity of species, — an hypothesis which multiplies species in an organism to meet emergencies, — the emergencies of theory, — much as the epicycles of Ptolemy had to be multiplied in the heavens. Ptolemy himself had the sagacity to believe that his was only a mathematical theory, a mode of representation, not a theory of causation; and to prize it only as representative of the facts of observation, or as "saving the appearances." Mr. Mivart's theory, on the other hand, is put forward as a theory of causation, not to save appearances, but to justify the hasty conclusion that they are real; the appearances, namely, of complete temporary fixity, alternating with abrupt changes, in the forms of life which are exhibited by the scanty records of geology and in present apparently unchanging natural species.

Before proceeding to a special consideration of our author's difficulties on the theory of Natural Selection, we will quote from Mr. Darwin's latest work, "The Descent of Man," his latest views of the extent of the action of this principle and its relations to the general theory of evolution. He says (Chapter IV.):—

"Thus a very large yet undefined extension may safely be given to the direct and indirect results of Natural Selection; but I now admit, after reading the essay by Nägeli on plants, and the remarks by various authors with respect to animals, more especially those recently made by Professor Broca, that in the earlier editions of my 'Origin of Species' I probably attributed too much to the action of Natural Selection, or the survival of the fittest. I have altered the fifth edition of the 'Origin' [the edition which Mr. Mivart reviews in his work], so as to confine my remarks to adaptive changes of structure. I had not formerly sufficiently considered the existence of many structures which

appear to be, as far as we can judge, neither beneficial nor injurious; and this I believe to be one of the greatest oversights as yet detected in my work. I may be permitted to say, as some excuse, that I had two distinct objects in view: firstly, to show that species had not been separately created; and secondly, that Natural Selection had been the chief agent of change, though largely aided by the inherited effects of habit, and slightly by the direct action of the surrounding conditions. Nevertheless, I was not able to annul the influence of my former belief, then widely prevalent, that each species had been purposely created; and this led to my tacitly assuming that every detail of structure, excepting rudiments, was of some special, though unrecognized, service. Any one with this assumption in his mind would naturally extend the action of Natural Selection, either during past or present times, too far. Some of those who admit the principle of evolution, but reject Natural Selection, seem to forget, when criticising my work, that I had the above two objects in view; hence, if I have erred in giving to Natural Selection great power, which I am far from admitting, or in having exaggerated its power, which is in itself probable, I have at least, as I hope, done good service in aiding to overthrow the dogma of separate creations."

In one other respect Mr. Darwin has modified his views of the action of Natural Selection, in consequence of a valuable criticism in the North British Review of June, 1867; and our author regards this modification as very important, and says of it that "this admission seems almost to amount to a change of front in the face of the enemy." It is not, as we shall see, an important modification at all, and does not change in any essential particular the theory as propounded in the first edition of the "Origin of Species," but our author's opinion of it has helped us to discover what, without this confirmation, seemed almost incredible, — how completely he has misapprehended, not merely the use of the theory in special applications, which is easily excusable, but also the nature of its general operation and of the causes employed by it; thus furnishing an additional illustration of what he says in his Introduction, that "few things are more remarkable than the way in which it [this theory] has been misunderstood." One other consideration has also been of aid to us. In his concluding chapter on "Theology and Evolution," in which he very ably shows, and on the most venerable authority, that there is no necessary

conflict between the strictest orthodoxy and the theory of evolution, he remarks (and quotes Dr. Newman) on the narrowing effect of single lines of study. Not only inabilities may be produced by a one-sided pursuit, but "a positive distaste may grow up, which, in the intellectual order, may amount to a spontaneous and unreasoning disbelief in that which appears to be in opposition to the more familiar concept, and this at all times." This is, of course, meant to apply to those who, from want of knowledge, also lack ability and interest and even acquire a distaste for theological studies. But it also has other and equally important applications. Mr. Mivart, it would at first sight seem, being distinguished as a naturalist and also versed in theology, is not trammelled by any such narrowness as to disable him from giving just weight to both sides of the question he discusses. But what are the two sides? Are they the view of the theologian and the naturalist? Not at all. The debate is between the theologian and descriptive naturalist on one side, or the theologian and the student of natural history in its narrowest sense, that is, systematic biology; and on the other side the physical naturalist, physiologist, or theoretical biologist. Natural history and biology, or the general science of life, are very comprehensive terms, and comprise in their scope widely different lines of pursuit and a wide range of abilities. In fact, the sciences of biology contain contrasts in the objects, abilities, and interests of scientific pursuit almost as wide as that presented by the physical sciences generally, and the sciences of direct observation, description, and classification. The same contrast holds, indeed, even in a science so limited in its material objects as astronomy. The genius of the practical astronomer and observer is very different from that of the physical astronomer and mathematician; though success in this science generally requires nowadays that some degree of both should be combined. So the genius of the physiologist is different from that of the naturalist proper, though in the study of comparative anatomy the observer has to exercise some of the skill in analysis and in the use of hypotheses which are the genius of the physical sciences in the search for unknown causes. We may, perhaps, comprise all the forms of intellectual genius (excluding æsthetics) under

three chief classes, namely, first, the genius that pursues successfully the researches for unknown causes by the skilful use of hypothesis and experiment; secondly, that which, avoiding the use of hypotheses or preconceptions altogether and the delusive influence of names, brings together in clear connections and contrasts in classification the objects of nature in their broadest and realest relations of resemblance; and thirdly, that genius which seeks with success for reasons and authorities in support of cherished convictions.

That our author may have the last two forms of genius, even in a notable degree, we readily admit; but that he has not the first to the degree needed for an inquiry, which is essentially a branch of physical science, we propose to show. We have already pointed out how his theological education, his schooling against Democritus, has misled him in regard to the meaning of "accidents" or accidental causes in physical science; as if to the physical philosopher these could possibly be an absolute and distinct class, not included under the law of causation, "that every event must have a cause or determinate antecedents," whether we can trace them out or not. The accidental causes of science are only "accidents" relatively to the intelligence of a man. Eclipses have the least of this character to the astronomer of all the phenomena of nature; yet to the savage they are the most terrible of monstrous accidents. The accidents of monstrous variation, or even of the small and limited variations normal in any race or species, are only accidents relatively to the intelligence of the naturalist, or to his knowledge of general physiology. An accident is what cannot be anticipated from what we know, or by any intelligence, perhaps, which is less than omniscient.

But this is not the most serious misconception of the accidental causes of science, which our author has fallen into. He utterly mistakes the particular class of accidents concerned in the process of Natural Selection. To make this clear, we will enumerate the classes of causes which are involved in this process. In the first place, there are the external conditions of an animal's or plant's life, comprising chiefly its relations to other organic beings, but partly its relations to inorganic nature, and determining its needs and some of the means of satisfying them.

These conditions are consequences of the external courses of events or of the partial histories of organic and inorganic nature. In the second place, there are the general principles of the fitness of means to ends, or of supplies to needs. These comprise the best ascertained and most fundamental of all the principles of science, such as the laws of mechanical, optical, and acoustical science, by which we know how a leg, arm, or wing, a bony frame, a muscular or a vascular system, an eye or an ear, can be of *use*. In the third place, there are the causes introduced by Mr. Darwin to the attention of physiologists, as normal facts of organic nature, the little known phenomena of variation, and their relations to the laws of inheritance. There are several classes of these. The most important in the theory of Natural Selection are the diversities *always existing* in any race of animals or plants, called "individual differences," which *always* determine a better fitness of some individuals to the general conditions of the existence of a race than other less fortunate individuals have. The more than specific agreements in characters, which the best fitted individuals of a race must thus exhibit, ought, if possible, according to Cuvier's principles of zoölogy, to be included in the description of a species (as a norm or type which only the *best* exhibit), instead of the rough averages to which the naturalist really resorts in defining species by marks or characters that are variable. But probably such averages in variable characters are really close approximations to the characters of the best general adaptation; for variation being, so far as known, irrespective of adaptation, is as likely to exist to the same extent on one side of the norm of utility as on the other, or by excess as generally as by defect. Though variation is irrespective of utility, its limits are not. Too great a departure from the norm of utility must put an end to life and its successions. Utility therefore determines, along with the laws of inheritance, not only the middle line or safest way of a race, but also the bounding limits of its path of life; and so long as the conditions and principles of utility embodied in a form of life remain unchanged, they will, together with the laws of inheritance, maintain a race unchanged in its average characters. "Specific stability," therefore, for which theological and descriptive naturalists have speculated a

transcendental cause, is even more readily and directly accounted for by the causes which the theory of Natural Selection regards than is specific change. But just as obviously it follows from these causes that a change in the conditions and resources of utility, not only may but must change the normal characters of a species, or else the race must perish. Again, a slow and gradual change in the conditions of existence must, on these principles, slowly change the middle line or safest way of life (the descriptive or graphic line); but always, of course, this change must be within the existing limits of variation, or the range of "individual differences." A change in these limits would then follow, or the range of "individual differences" would be extended, at least, so far as we know, in the direction of the change. That it is widened or extended to a greater range by rapid and important changes in conditions of existence, is a matter of observation in many races of animals and plants that have been long subject to domestication or to the capricious conditions imposed by human choice and care. This phenomenon is like what would happen if a roadway or path across a field were to become muddy or otherwise obstructed. The travelled way would swerve to one side, or be broadened, or abandoned, according to the nature and degree of the obstruction, and to the resources of travel that remained. This class of variations, that is, "individual differences," constant and normal in a race, but having different ranges in different races, or in the same race under different circumstances, may be regarded as in no proper sense accidentally related to the advantages that come from them; or in no other sense than a tendril, or a tentacle, or a hand searching in the dark, is accidentally related to the object it succeeds in finding. And yet we say properly that it was by "accident" that a certain tendril was put forth so as to fulfil its function, and clasp the particular object by which it supports the vine; or that it was an accidental movement of the tentacle or hand that brought the object it has secured within its grasp. The search was, and continues to be, normal and general; it is the particular success only that is accidental; and this only in the sense that lines of causation, stretching backwards infinitely, and unrelated except in a first cause, or in the total order of nature,

come together and by their concurrence produce it. Yet over even this concurrence "law" still presides, to the effect that for every such concurrence the same consequences follow.

But our author, with his mind filled with horror of "blind chance," and of "the fortuitous concourse of atoms," has entirely overlooked the class of accidental variations, on which, even in the earlier editions of the "Origin of Species," the theory of Natural Selection is based, and has fixed his attention exclusively on another class, namely, abnormal or unusual variations, which Mr. Darwin at first supposed might also be of service in this process. The fault might, perhaps, be charged against Mr. Darwin for not sufficiently distinguishing the two classes, as well as overlooking, until it was pointed out by his critic in the "North British Review," before referred to, the fact that the latter class could be of no service; if it were not that our author's work is a review of the last edition of the "Origin of Species" and of the treatise on "Animals and Plants under Domestication," in both of which Mr. Darwin has emphatically distinguished these classes, and admitted that it is upon the first class only that Natural Selection can normally depend; though the second class of unusual and monstrous variations may give rise, by highly improbable though possible accidents, to changes in the characters of whole races. Mr. Mivart characterizes this admission by the words we have quoted, that "it seems almost to amount to a change of front in the face of the enemy"; of which it might have been enough to say, that the strategy of science is not the same as that of rhetorical disputation, and aims at cornering facts, not antagonists. But Mr. Mivart profits by it as a scholastic triumph over heresy, which he insists upon celebrating, rather than as a correction of his own misconceptions of the theory. He continues throughout his book to speak of the variations on which Natural Selection depends as if they were all of rare occurrence, like abrupt and monstrous variations, instead of being always present in a race; and also as having the additional disadvantage of being "individually slight," "minute," "insensible," "infinitesimal," "fortuitous," and "indefinite." These epithets are variously combined in different passages, but his favorite compendious formula is, "minute, fortuitous, and indefinite variations."

When, however, he comes to consider the enormous time which such a process must have taken to produce the present forms of life, he brings to bear all his forces, and says (p. 154): "It is not easy to believe that less than two thousand million years would be required for the totality of animal development by no other means than minute, fortuitous, occasional, and intermitting variations in all conceivable directions." This exceeds very much — by some two hundred-fold — the length of time Sir William Thomson allows for the continuance of life on the earth. It is difficult to see how, with such uncertain "fortuitous, occasional, and intermitting" elements, our author could have succeeded in making any calculations at all. On the probability of the correctness of Sir William Thomson's physical arguments "the author of this book cannot presume to advance an opinion; but," he adds (p. 150), "the fact that they have not been refuted pleads strongly in their favor when we consider how much they tell against the theory of Mr. Darwin." He can, it appears, judge of them on his own side.

For the descriptive epithets which our author applies to the variations on which he supposes Natural Selection to depend he has the following authority. He says (p. 35): "Now it is distinctly enunciated by Mr. Darwin that the spontaneous variations upon which his theory depends are individually slight, minute, and insensible. He says (*Animals and Plants under Domestication*, Vol. II. p. 192): 'Slight individual differences, however, suffice for the work, and are probably the sole differences which are effective in the production of new species.'" After what we have said as to the real nature of the differences from which nature selects, it might be, perhaps, unnecessary to explain what ought at least to have been known to a naturalist, that by "individual differences" is meant the differences between the individuals of a race of animals or plants; that the slightness of them is only relative to the differences between the characters of species, and that they may be very considerable in themselves, or their effects, or even to the *eye* of the naturalist. How the expression "slight individual differences" could have got translated in our author's mind into "individually slight, minute, and insensible" ones, has no natural expla-

nation. But this is not the only instance of such an unfathomable translation in our author's treatment of the theory of Natural Selection. Two others occur on page 133. In the first he says: "Mr. Darwin abundantly demonstrates the variability of dogs, horses, fowls, and pigeons, but he none the less shows the *very small* extent to which the goose, the peacock, and the guinea-fowl have varied. Mr. Darwin attempts to explain this fact as regards the goose by the animal being valued only for food and feathers, and from no pleasure having been felt in it on other accounts. He adds, however, at the end, the striking remark, which concedes the whole position, 'but the goose seems to have *a singularly inflexible organization.*'" The translation is begun in the author's italics, and completed a few pages further on (p. 141), where, recurring to this subject, he says: "We have seen that Mr. Darwin himself implicitly admits the principle of specific stability in asserting the singular inflexibility of the organization of the goose." This is what is called in scholastic logic, *Fallacia a dicto secundum quid ad dictum simpliciter.* The obvious meaning, both from the contexts and the evidence, of the expression "singularly inflexible," is that the goose has been much less changed by domestication than other domestic birds. But this *relative* inflexibility is understood by our author as an admission of an *absolute* one, in spite of the evidence that geese have varied from the wild type, and have individual differences, and even differences of breeds, which are sufficiently conspicuous, even to the eye of a goose. The next instance of our author's translations (p. 133) is still more remarkable. He continues: "This is not the only place in which such expressions are used. He [Mr. Darwin] elsewhere makes use of phrases which quite harmonize with the conception of a normal specific constancy, but varying greatly and suddenly at intervals. Thus he speaks of a *whole organism seeming to have become plastic and tending to depart from the parental type* ('Origin of Species,' 5th edit., 1869, p. 13)." The italics are Mr. Mivart's. The passage from which these words are quoted (though they are not put in quotation-marks) is this: "It is well worth while carefully to study the several treatises on some of our old cultivated plants, as on the hyacinth, potato, even the dahlia,

etc.; and it is really surprising to note the endless points in structure and constitution in which the varieties and sub-varieties differ slightly from each other. The whole organization seems to have become plastic, and tends to depart *in a slight degree* from that of the parental type." The words that we have italicized in this quotation are omitted by our author, though essential to the point on which he cites Mr. Darwin's authority, namely, as to the organism "varying greatly and suddenly at intervals." Logic has no adequate name for this fallacy; but there is another in our author's understanding of the passage which is very familiar, — the fallacy of ambiguous terms. Mr. Darwin obviously uses the word "plastic" in its secondary signification as the name of that which is "capable of being moulded, modelled, or fashioned to the purpose, as clay." But our author quite as obviously understands it in its primary signification as the name of anything "having the power to give form." But this is a natural enough misunderstanding, since in scholastic philosophy the primary signification of "plastic" is the prevailing one.

Such being our author's misconceptions of the principle of Natural Selection, and such their source, it would be useless to follow him in his tests of it by hypothetical illustrations from the history of animals; but we are bound to make good our assertion that the author's difficulties have arisen, not only from his want of a clear mental grasp of principles, but also from an inadequate knowledge of the resources of legitimate hypothesis to supply the unknown incidental causes through which the principle has acted. These deficiencies of knowledge and imagination, though more excusable, are not less conspicuous in his criticisms than the defects we have noticed. He says (p. 59): "It may be objected, perhaps, that these difficulties are difficulties of *ignorance;* that we cannot explain them, because we do not know *enough* of the animals." It is not surprising that he adds: "But it is here contended that this is not the case; it is not that we merely fail to see how Natural Selection acted, but that there is a positive incompatibility between the cause assigned and the results." And no wonder that he remarks at the close of the chapter (Chapter II.): "That minute, fortuitous, and indefinite varia-

tions could have brought about such special forms and modifications as have been enumerated in this chapter seems to contradict, not imagination, but reason."

In this chapter on "Incipient Structures," the fact is quite overlooked, which is so conspicuous in the principles of comparative anatomy, how few the fundamental structures are, which have been turned to such numerous uses; how meagre have been the resources of Natural Selection, so far as it has depended on the occurrence of structures which were of no previous use, or were not already partially useful in directions in which they have been modified by the selection and inheritance of "individual differences"; or how important to Natural Selection have been the principles of indirect utility and "correlated acquisition," dependent on ultimate physical laws. The human hand is still useful in swimming, and the fishes' fins could even be used for holding or clasping, if there were occasion for it. We might well attribute the paucity of indifferent types of structure to the agency of the rarest accidents of nature, though not in a theological sense. Animals and plants are no longer dependent for improvement on their occurrence, and, perhaps, never were after their competition and struggle for existence had fully begun. It is so much easier for them to turn to better account powers that they already possess in small degrees. Previously to such a competition and struggle, when the whole field of the inorganic conditions of life was open to simple organisms, they were doubtless much more variable than afterwards. But variability would then have been, as it is now, in no absolute sense accidental. On the contrary, variation would have been, instead of comparative stability in species, the most prominent normal feature of life. The tentative powers of life, instead of its hereditary features, trying all things, but not holding fast to that which is good, or not so firmly as afterwards, would have been its most characteristic manifestation. Our author's general difficulty in this chapter is as to how variations too small to have been of use could have been preserved, and he is correct in thinking that it could not be by Natural Selection, or the survival of the fittest, but wrong in thinking that variations are generally so rare or so insignificant, even in present

forms of life as to require a power other than those of life in general to bring them forth when needed, or to produce them in useful amounts.

The first example of the working of Natural Selection is the well-known case of the neck of the giraffe. This, it has been imagined, though not by Mr. Darwin, was produced by its supposed use in aiding this animal to feed on the foliage of trees, and by the occasional advantage it would give to the highest reaching individuals, when in drought and scarcity the ground vegetation and lower foliage was consumed, and by thus enabling them to survive the others and continue the species, transmitting this advantage to their offspring. Without denying that this is an excellent hypothetical illustration of the process of Natural Selection, Mr. Mivart attacks its probability as a matter of fact. In reply to it he says: "But against this it may be said, in the first place, that the argument proves too much; for, on this supposition, many species must have tended to undergo a similar modification, and we ought to have at least several forms similar to the giraffe developed from different *Ungulata*," or hoofed beasts. We would even go further than Mr. Mivart, and hold that, on the hypothesis in question, not only several forms, but the whole order of *Ungulata*, or large portions of it, should have been similarly modified; at least those inhabiting regions subject to droughts and presenting the alternative of grazing on the ground and browsing on the foliage of high trees. But as these alternatives do not universally exist in regions inhabited by such animals, very long necks would not, perhaps, characterize the whole order, if this hypothesis were true; as the habit of herding does, for example. We may observe, however, that this illustration from the giraffe's neck is not an *argument* at all, and proves nothing, though the hypothesis employed by it is very well called in question by Mr. Mivart's criticism. But can Mr. Mivart suppose that, having fairly called in question the importance of the high-feeding use of the giraffe's neck, he has thereby destroyed the utility of the neck altogether, not only to the theory of Natural Selection, but also to the animal itself? Is there, then, no important use in the giraffe's neck? Is it really the monstrosity it appears to be, when seen out of rela-

tion to the normal conditions of the animal's life? But if there be any utility left in the neck, as a teleologist or a believer in Final Causes would assume without question, and in spite of this criticism, then it might serve the purposes of Natural Selection even better perhaps than that of the mistaken hypothesis. If our author had approached this subject in the proper spirit, his criticism would probably have led him to an important observation, which his desire to discredit a much more important discovery has hidden from his view. He would have inquired what are the conditions of existence of the Ungulates generally and of the giraffe in particular, which are so close pressing and so emphatically attest the grounds of their severest struggle for life, as to be likely to cause in them the highest degree of specialty and adaptation. The question of food is obviously not concerned in such a struggle, for this order of animals lives generally upon food which is the most abundant and most easily obtained. Mr. Mivart compares his objection to one that has been made against Mr. Wallace's views as to the uses of color in animals, that "color being dangerous, should not exist in nature," or that "a dull color being needful, all animals should be so colored." He quotes Mr. Wallace's reply, but does not take the clew to the solution of his difficulty respecting the giraffe's neck, which it almost forces on him. This reply was, that many animals can afford brilliant colors, and their various direct uses or values, when the animals are otherwise provided with sufficient protection, and that brilliant colors are even sometimes indirectly protective. The quills of the porcupine, the shells of tortoises and mussels, the very hard coats of certain beetles, the stings of certain other insects, the nauseous taste of brilliantly colored caterpillars, and other instances, are given as examples. Now, what bearing has this on the long neck of the giraffe? According to our author, who is himself at this point on the defensive, it is as follows. He says: "But because many different kinds of animals can elude the observation or defy the attack of enemies in a great variety of ways, it by no means follows that there are any similar number and variety of ways for attaining vegetable food in a country where all such food other than the lofty branches of trees has been destroyed. In such a country we have a number

of vegetable-feeding Ungulates, all of which present minute variations as to the length of the neck." Mr. Mivart is apparently not aware that he is here arguing, not against the theory of Natural Selection, but against a subordinate and false hypothesis under it. But if he thinks thus to undermine the theory, it must be because he is not aware of, or has not present to his imagination, the numberless ingenuities of nature, and the resources of support the theory has to rest upon. There can be no doubt that the neck of the giraffe, whatever other uses it can be put to, and it is put to several, is pre-eminently useful as a *watch-tower*. Its eyes, large and lustrous, "which beam with a peculiarly mild but fearless expression, are so placed as to take in a wider range of the horizon than is subject to the vision of any other quadruped. While browsing on its favorite acacia, the giraffe, by means of its laterally projecting orbits, can direct its sight so as to anticipate a threatened attack in the rear from the stealthy lion or any other foe of the desert." When attacked, the giraffe can defend itself by powerful blows with its well-armed hoofs, and even its short horns can inflict fatal blows by the sidelong swing of its neck. But these are not its only protections against danger. Its nostrils can be voluntarily closed, like the camel's, against the sandy, suffocating clouds of the desert. "The tail of the giraffe looks like an artificially constructed fly-flapper; and it seems at first incredible," says Mr. Darwin, "that this could have been adapted for its present purpose by successive slight modifications, each better and better fitted, for so trifling an object as to drive away flies; yet we should pause before being too positive, even in this case, for we know that the distribution and existence of cattle and other animals in South America absolutely depend on their power of resisting the attacks of insects; so that individuals which could, by any means, defend themselves from these small enemies, would be able to range into new pastures, and thus gain a great advantage. It is not that the larger quadrupeds are actually destroyed (except in rare cases) by flies, but they are incessantly harassed and their strength reduced, so that they are more subject to disease, or not so well enabled in a coming dearth to search for food, or to escape from beasts of prey."

This passage recalls our main problem, which does not concern the giraffe alone, but all the Ungulates; and its solution will show that this order of animals exhibits, almost as well as Mr. Wallace's examples, the resources that nature has for the protection of animals that have the disadvantage, not, indeed, generally of brilliant colors, but of exposure by living exclusively on bulky and comparatively innutritious food. Nearly all the resources of defensive warfare are exhausted in their specialties of protection. The giraffe alone is provided with a natural watch-tower, but the others are not left without defence. All, or nearly all, live in armies or herds, and some post sentinels around their herds. The numerous species of the antelope resort to natural fortifications or fastnesses. "They are the natives for the most part of the wildest and least accessible places in the warmer latitudes of the globe, frequenting the cliffs and ledges of mountain rocks or the verdure-clad banks of tropical streams, or the oases of the desert." Other tribes depend on their fleetness, and on hiding in woods like the deer. Others, again, on great powers of endurance in flight and long marches, like the camels with their commissaries of provision. Others, again, with powerful frames, like the rhinoceros and the bisons, resort to defensive attack. The ruminant habits and organs of large numbers are adapted to rapid and dangerous foraging, and to digestion under protection from beasts of prey and insects.

But our author, with little fertility of defence for the theory of Natural Selection, is still not without some ingenuity in attack. He objects, in the second place, that the longest necked giraffes, being by so much the larger animals, would not be strong in proportion, but would need more food to sustain them, a disadvantage which would, perhaps, more than outbalance the long neck in times of drought; and he cites Mr. Spencer's ingenious speculations on the relations of size, food, and strength, in confirmation of this objection. But he forgets or overlooks the important physiological law of the compensation or economy of growth which prevails in variations. A longer neck does not necessarily entail a greater bulk or weight on the animal as a whole. The neck may have grown at the expense of the hind parts in the ancestors of the giraffe. If we

met with an individual man with a longer neck than usual, we should not expect to find him heavier, or relatively weaker, or requiring more food on that account. But let us pass to the next illustration of the insufficiency of Natural Selection. This is the difficulty our author finds in attributing to this cause various cases of mimicry or protective resemblances of animals to other animals, or to other natural objects. In some insects this is carried to a wonderful extent. Thus, some which imitate leaves when at rest, in the sizes, shapes, colors, and markings of their wings, "extend the imitation even to the very injuries on those leaves made by the attacks of insects or fungi." Thus Mr. Wallace says of the walking-stick insects: "One of these creatures, obtained by myself in Borneo, was covered over with foliaceous excrescences of a clear olive-green color so as exactly to resemble a stick grown over by creeping moss or jungermannia. The Dyak who brought it me assured me it was grown over with moss, although alive, and it was only after a most minute examination that I could convince myself it was not so." And in speaking of the leaf-butterfly, he says: "We come to a still more extraordinary part of the imitation, for we find representations of leaves in every stage of decay, variously blotched and mildewed, and pierced with holes, and in many cases irregularly covered with powdery black dots, gathered into patches and spots, so closely resembling the various kinds of minute fungi that grow on dead leaves that it is impossible to avoid thinking, at first sight, that the butterflies themselves have been attacked by real fungi." Upon these passages our author remarks: "Here imitation has attained a development which seems utterly beyond the power of the mere 'survival of the fittest' to produce. How this double mimicry can importantly aid in the struggle for life seems puzzling indeed, but much more so how the first beginnings of the imitation of such injuries in the leaf can be developed in the animal into such a complete representation of them; *a fortiori*, how simultaneous and similar first beginnings of imitations of such injuries could ever have been developed in several individuals, out of utterly indifferent and indeterminate infinitesimal variations in all conceivable directions."

What ought to have been first suggested to a naturalist by

this wonderful mimicry is, what clever entomologists some insectivorous birds must have become to be able to press the conditions of existence and the struggle for life in these insects to such a degree of specialty. But this, after all, is not so very wonderful, when we consider what microscopic sight these birds must have acquired and what practice and exclusive interest in the pursuit! We may feel pretty confident, however, that neither Natural Selection nor any occult or transcendental cause has ever carried protective mimicry beyond eyesight, though it may well be a better eyesight than that even of a skilful naturalist. There is no necessity to suppose, with our author, that the variations on which this selection depended were either simultaneous, or infinitesimal, or indifferent, for "individual differences" are always considerable and generally greatest in directions in which variations have already most recently occurred, as in characters in which closely allied races differ most from each other; but, doubtless, a very long time was required for these very remarkable cases of mimicry to have come to pass. Their difficulties resemble those of the development of sight itself, on which our author comments elsewhere; but in these particular cases the conditions of "hide and seek" in the sport of nature present correlated difficulties, which, like acid and alkali, serve to neutralize each other. In these cases, four distinct forms of life of widely diverse origins, or very remotely connected near the beginnings of life itself, like four main branches of a tree, have come together into closest relations, as parts of the foliage of the four main branches might do. These are certain insectivorous birds, certain higher vegetable forms, the imitated sticks or leaves, certain vegetable parasites on them, and the mimicking insects. But the main phenomenon was and is the neck-and-neck race of variation and selection between the powers of hiding in the insect and the powers of finding in the bird. Our author overlooks the fact that variations in the bird are quite as essential to the process as those of the insect, and has chosen to consider elsewhere the difficulties which the developments of the eye present, and in equal independence of its obvious uses. The fact that these, as well as other extraordinary cases of mimicry, are found only in tropical climates, or climates

equable not only in respect to short periodic but also secular changes, accords well with the probable length of time in which this competition has been kept up; and the extraordinary, that is, rare character of the phenomenon agrees well with the probable supposition that it has always begun in what we call in science "an accident." If its beginnings were common, their natural consequences would also be common, and would not be wonderful; and if it arose from a destructive, unintelligent, evil principle, — from Ahriman, — it has, at least, shown how the course of nature has been able to avoid destruction, to the astonishment of human intelligence, and how Oromasdes has been able to defeat his antagonist by turning evil into good.

Let us take next our author's treatment of a supposed origin of the mammary, or milk glands: —

"Is it conceivable," he asks (p. 60), "that the young of any animal was ever saved from destruction by accidentally sucking a drop of scarcely nutritious fluid from an accidentally hypertrophied cutaneous gland of its mother? And even if one was so, what chance was there of the perpetuation of such a variation? On the hypothesis of 'Natural Selection' itself we must assume that, up to that time, the race had been well adapted to the surrounding conditions; the temporary and accidental trial and change of conditions, which caused the so-sucking young one to be the 'fittest to survive' under the supposed circumstances, would soon cease to act, and then the progeny of the mother, with the accidentally hypertrophied sebaceous glands, would have no tendency to survive the far outnumbering descendants of the normal ancestral form."

Here, as before, our author stakes the fate of the theory on the correctness of his own conceptions of the conditions of its action. He forgets, first of all, that the use of a milk gland in its least specialized form requires at least a sucking mouth, and that sucking mouths and probosces have very extensive uses in the animal kingdom. They are good for drinking water and nectar, and are used for drawing blood as well as milk; and, without reference to alimentation, are still serviceable for *support* to parasitical animals. Might not the young, which before birth are, in a high degree, parasitical in all animals, find it highly advantageous to continue the habit after birth, even without reference to food, but for the generally quite as impor

tant use of protection against enemies, by clinging by a sucking mouth to the body of its dam? If this should cause sebaceous glands to become hypertrophied and ultimately a valuable or even an exclusive source of nutrition, it would, perhaps, be proper to describe the phenomenon as an unintended or accidental, but not as a rare or improbable one. Moreover, though on the theory of Natural Selection (or, indeed, on any theory of the continuance of a race by modifications of structures and habits), the race must, while it lives, be fitted to live, yet it need be no more fitted to do so than to survive in its offspring. No race is so well fitted to its general conditions of existence, but that some individuals are better fitted than others, and have, on the average, an advantage. And new resources do not imply abandonment of the old, but only additions to them, giving superiorities that are almost never superfluous. How, indeed, but by accidents of the rarest occurrence, could variation (much less selection) give superfluous advantages, on the whole, or except temporarily and so far as normal variations anticipate in general, regular, or usual changes in the conditions of existence? We have, to be sure, on the hypothesis we have proposed, still to account for the original of the sucking mouth, though its numerous uses are obvious enough, on the really uniform and unvarying types of natural law, the laws of inorganic physics, the principles of suction. But we are not ambitious to rival nature in ingenuity, only to contrast its resources with those of our naturalist. His next example is a criticism of the theory of Sexual Selection. Speaking of apes, he says: "When we consider what is known of the emotional nature of these animals and the periodicity of its intensification, it is hardly credible that a female would often risk life or limb through her admiration of a trifling shade of color or an infinitesimally greater, though irresistibly fascinating degree of wartiness." Is it credible that Mr. Mivart can suppose that the higher or spiritual emotions, like affection, taste, conscience, ever act *directly* to modify or compete with the more energetic lower impulses, and not rather by forestalling and indirectly regulating them, as by avoiding temptation in the case of conscience; or by establishing social arrangements, companionships, friendships, and more or less permanent marriages in

the case of sexual preferences? All such arrangements, all grounds for the action of taste or admiration, or any but the most monstrous friendships, are prevented or removed in the lives of caged beasts. His example and his inference from it are as much as if an explorer should discover a half-famished tribe of savages sustaining life upon bitter and nauseous food, and should conclude that not only these but all savages, the most provident, or even all men, are without any choice in food, and that in providing for future wants they are influenced by no other considerations than the grossest cravings of appetite.

But to return to Natural Selection. The next example is that of the rattling and expanding powers of poisonous snakes. The author says that "in poisonous serpents, also, we have structures which, at all events, at first sight, seem positively hurtful to these reptiles. Such are the rattle of the rattlesnake and the expanding neck of the cobra, the former serving to warn the ear of the intended victim as the latter warns the eye." This "first sight" is all the use our author discovers in these organs; but why should these warnings be intended or used to drive away intended *victims* rather than *enemies?* Or is it among the intentions of nature to defeat those in the serpent? If the effects of such "warnings" really were to deprive these snakes of their proper food, would not experience itself and intelligence be sufficient in the wily serpent to correct such perverse instincts? It is, indeed, at first sight, curious that certain snakes, though these are the sluggish kinds, and cannot so easily escape their enemies by flight as others can, should be provided, not only with poisonous fangs, but with these means of warning either victims or dangerous enemies. But Mr. Wallace has furnished a clew to their correlation by his example of the relations between conspicuous colors and nauseous tastes in many caterpillars, the color serving as a sign of the taste and warning birds not to touch these kinds. The poisonous fang and its use are expensive and risky means of defence; the warnings associated with them are cheap and safe. But if, as is very likely, these "warnings" are also used against intended victims, they can only be used either to paralyze them with terror or allure them from curiosity, or to

produce in them that curious and paralyzing mixture of the two emotions, alarm and something like curiosity, which is all that is probably true of the supposed powers of fascination * in serpents. Perhaps, also, the rattle serves to inspire the sluggish snake itself with courage; and in this case the rattle will serve all the purposes that drums, trumpets, and gongs do in human warfare. The swaying body and vibrating tongue of most snakes, and the expanding neck and the hood of the cobras, may serve for banners. But the rattle has also been supposed to serve as a sexual call, very much as the inspirations of warfare are turned into the allurements of the tournament, or as gongs also serve to call travellers to dinner. What poverty of resources in regard to the relations of *use* in the lives of animals thus distinguishes our naturalist from the natural order of things! What wealth and capital are left for the employments and industries of Natural Selection!

In the next chapter our author charges the theory of Natural Selection with inability to account for independent similarities of structure; "that it does not harmonize with the coexistence of closely similar structures of diverse origin," like the dental structures in the dog and in the carnivorous marsupial, the Thylacine, closely similar structures and of exactly the same utilities, though belonging to races so diverse that their common ancestors could not have been like them in respect to this resemblance. But these structures really differ in points not essential to their utilities; in characters which, though inconspicuous, are marks of the two great divisions of mammalia, to which these animals belong. Our author here attacks the theory in its very citadel, and has incautiously left a hostile force in his rear. He has claimed in the preceding chapter for Natural Selection that it ought to have produced several independent races of long-necked Ungulates, as well as the giraffe; so that, instead of pursuing his illustrations any further, we

* This is a real condition of mind in the subject of it; a condition in which interest or emotion gives to an idea such fixity and power that it takes possession at a fatal moment of the will and acts itself out; as in the fascination of the precipice. It is not, however, to be regarded as a natural contrivance in the mental acquisitions of the victims for the benefit of the serpent any more than the serpent's warnings are for their benefit; but as a consequence of ultimate mental laws in general, of which the serpent's faculties and habits take advantage.

may properly demand his surrender. Of course Natural Selection requires for similar products similar means and conditions; but these are of such a general sort that they belong to wide ranges of life; and as it does not act by "blind chance," or theological accidents, but by the invariable laws of nature and the tentative powers of life, it is not surprising that it often repeats its patterns independently of descent, or of the copying powers of inheritance.

That the highest products of nature are not the results of the mere forces of inheritance, and do not come from the birth of latent powers and structures, seems to be the lesson of the obscure discourse in which Jesus endeavored to instruct Nicodemus the Pharisee. How is it that a man can be born again, acquire powers and characters that are not developments of what is already innate in him? How is it possible when he is old to acquire new innate principles, or to enter a second time into his mother's womb and be born? The reply does not suggest our author's hypothesis of a life turning over upon a new "facet," or a new set of latent inherited powers. Only the symbols, water and the Spirit, which Christians have ever since worshipped, are given in reply; but the remarkable illustration of the accidentality of nature is added, which has been almost equally though independently admired. "Marvel not that I said unto thee, Ye must be born again. The wind bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh and whither it goeth; so is every one that is born of the Spirit." The highest products of nature are the outcome of its total and apparently accidental orders; or are born of water and the Spirit, which symbolize creative power. To this the Pharisee replied: "How can these things be?" And the answer is still more significant: "Art thou a master of Israel and knowest not these things?" We bring natural evidences, "and ye receive not our witness. If I have told you earthly (natural) things, and ye believe not, how shall ye believe if I tell you heavenly (supernatural) things?" The bearing of our subject upon the doctrine of Final Causes in natural history has been much discussed and is of considerable importance to our author's theory and criticism. But we propose, not only to distinguish between this branch of theology

and the theories of inductive science on one hand, but still more emphatically, on the other hand, between it and the Christian faith in divine superintendency, which is very liable to be confounded with it. The Christian faith is that even the fall of a sparrow is included in this agency, and that as men are of more value than many sparrows, so much more is their security. So far from weakening this faith by showing the connection between value and security, science and the theory of Natural Selection have confirmed it. The very agencies that give values to life secure them by planting them most broadly in the immutable grounds of utility. But Natural Theology has sought by Platonic, not Christian, imaginations to discover, not the relations of security to value, but something *worthy* to be the source of the value considered as *absolute*, some particular worthy source of each valued end. This is the motive of that speculation of Final Causes which Bacon condemned as sterile and corrupting to philosophy, interfering, as it does, with the study of the facts of nature, or of what *is*, by preconceptions, necessarily imperfect as to what *ought to be;* and by deductions from assumed *ends*, thought worthy to be the purposes of nature. The naturalists who "take care not to ascribe to God any intention," sin rather against the spirit of Platonism than that of Christianity, while obeying the precepts of experimental philosophy. Though, as our author says, in speaking of the moral sense and the impossibility, as he thinks, that the accumulations of small repugnances could give rise to the strength of its abhorrence and reprobation; though, as he says, "no stream can rise higher than its source"; while fully admitting the truth of this, we would still ask, Where is its source? Surely not in the little fountains that Platonic explorers go in search of, *a priori*, which would soon run dry but for the rains of heaven, the water and the vapor of the distilling atmosphere. Out of this come also the almost weightless snow-flakes, which, combined in masses of great gravity, fall in the avalanche. The results of moralizing Platonism should not be confounded with the simple Christian faith in Divine superintendence. The often-quoted belief of Professor Gray, "that variation has been led along certain beneficial lines, like a stream along definite lines of irrigation,"

might be interpreted to agree with either view. The lines on which variations are generally useful are lines of search, and their particular successes, dependent, it is true, on no theological or absolute accidents, may be regarded as being lines of beneficial variations, seeing that they have resulted through laws of nature and principles of utility in higher living forms, or even in continuing definite forms of life on the earth. But thousands of movements of variation, or efforts of search, have not succeeded to one that has. These are not continued along evil lines, since thousands of forms have perished in consequence of them for every one that has survived.

The growth of a tree is a good illustration of this process, and more closely resembles the action of selection in nature generally than might at first sight appear; for its branches are selected growths, a few out of many thousands that have begun in buds; and this rigorous selection has been effected by the accidents that have determined superior relations in surviving growths to their supplies of nutriment in the trunk and in exposure to light and air. This exposure (as great as is consistent with secure connection with the sources of sap) seems actually to be sought, and the form of the tree to be the result of some foresight in it. But the real seeking process is budding, and the geometrical regularity of the production of buds in twigs has little or nothing to do with the ultimate selected results, the distributions of the branches, which are different for each individual tree. Even if the determinate variations really existed, — the "facets" of stable equilibrium in life, which our author supposes, — and were arranged with geometrical regularity on their spheroid of potential forms, as leaves and buds are in the twig, they would probably have as little to do with determining the ultimate diversities of life under the action of the selection which our author admits as phyllotaxy has to do with the branching of trees. But phyllotaxy, also, has its utility. Its orders are the best for packing of the incipient leaves in the bud, and the best for the exposure to light and air of the developed leaves of the stem. But here its utility ends, except so far as its arrangements also present the greatest diversity of finite elements, within the smallest limits, for the subsequent choice of successful growths; being *the nearest*

approaches that finite regularity could make to "indefinite variations in all conceivable directions." The general resemblance of trees of a given kind depends on no formative principle other than physical and physiological properties in the woody tissue, and is related chiefly to the tenacity, flexibility, and vascularity of this tissue, the degrees of which might almost be inferred from the general form of the tree. It cannot be doubted, in the case of the tree, that this tentative though regular budding has been of service to the production of the tree's growth, and that the particular growths which have survived and become the bases of future growths were determined by a beneficial though accidental order of events under the total orders of the powers concerned in the tree's development. But if a rigorous selection had not continued in this growth, no proper branching would have resulted. The tree would have grown like a cabbage. Hence it is to selection, and not to variation, — or rather to the *causes* of selection, and not to those of variation, — that species or well-marked and widely separated forms of life are due. If we could study the past and present forms of life, not only in different continents, which we may compare to different individual trees of the same kind, or better, perhaps, to different main branches from the same trunk and roots, but could also study the past and present forms of life in different planets, then diversities in the general outlines would probably be seen similar to those which distinguish different kinds of trees, as the oak, the elm, and the pine; dependent, as in these trees, on differences in the physical and physiological properties of living matters in the different planets, — supposing the planets, of course, to be capable of sustaining life, like the earth, or, at least, to have been so at some period in the history of the solar system. We might find that these general outlines of life in other planets resemble elms or oaks, and are not pyramidal in form like the pine, with a "crowning" animal like man to lead their growths. For man, for aught we know or could guess (but for the highly probable accidents of nature, which blight the topmost terminal bud and give ascendency to some lateral one), except for these accidents, man *may* have always been the crown of earthly creation, or always "man," if you choose so to name and define the creature who, though once an as-

cidian (when the ascidian was the highest form of life), *may* have been the *best* of the ascidians. This would, perhaps, add nothing to the present value of the race, but it might satisfy the Platonic demand that the race, though not derived from a source quite worthy of it, yet should come from the *best* in nature.

We are thus led to the final problem, at present an apparently insoluble mystery, of the origin of the first forms of life on the earth. On this Mr. Darwin uses the figurative language of religious mystery, and speaks "of life with its several powers being originally breathed by the Creator into a few forms or into one." For this expression our author takes him to task, though really it could mean no more than if the gravitative properties of bodies were referred directly to the agency of a First Cause, in which the philosopher professed to believe; at the same time expressing his unwillingness to make hypotheses, that is, transcendental hypotheses, concerning occult modes of action. But life is, indeed, divine, and there is grandeur in the view, as Mr. Darwin says, which derives from so simple yet mysterious an origin, and "from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals." Our author, however, is much more "advanced" than Mr. Darwin on the question of the origin of life or archigenesis, and the possibility of it as a continuous and present operation of nature. He admits what is commonly called "spontaneous generation," believing it, however, to be not what in theology is understood by "spontaneous," but only a sudden production of life by chemical synthesis out of inorganic elements. The absence of decisive evidence on this point does not deter him, but the fact that the doctrine can be reconciled to the strictest orthodoxy, and accords well with our author's theory of sudden changes in species, appears to satisfy him of its truth. The theory of Pangenesis, on the other hand, invented by Mr. Darwin for a different purpose, though not inconsistent with the very slow generation of vital forces out of chemical actions, — slow, that is, and insignificant compared to the normal actions and productions of chemical forces, — is hardly compatible with the sudden and conspicuous appearance

of new life under the microscope of the observer. This theory was invented like other provisional theories, — like Newton's corpuscular theory of light, like the undulatory theory of light (though this is no longer provisional), and like the chemical theory of atoms, — for the purpose of giving a material or visual basis to the phenomena and empirical laws of life in general, by embodying in such supposed properties the phenomena of development, the laws of inheritance, and the various modes of reproduction, just as the chemical theory of atoms embodies in visual and tangible properties the laws of definite and multiple proportions, and the relations of gaseous volumes in chemical unions, together with the principle of isomerism and the relations of equivalent weights to specific heats. The theory of Pangenesis presents life and vital forces in their ultimate and essential elements as perfectly continuous, and in great measure isolated from other and coarser orders of forces, like the chemical and mechanical, except so far as these are the necessary theatres of their actions. Gemmules, or vital molecules, the smallest bodies which have separable parts under the action of vital forces, and of the same order as the scope of action in these forces, — these minute bodies, though probably as much smaller than chemical molecules as these are smaller than rocks or pebbles, may yet exist in unorganized materials as well as in the germs of eggs, seeds, and spores, just as crystalline structures or chemical aggregations may be present in bodies whose form and aggregation are mainly due to mechanical forces. And, as in mechanical aggregations (like sedimentary rocks), chemical actions and aggregations slowly supervene and give in the metamorphosis of these rocks an irregular crystalline structure, so it is supposable that finer orders of forces lying at the heart of fluid matter may slowly produce imperfect and irregular vital aggregations. But *definite* vital aggregations and *definite* actions of vital forces exist, for the most part, in a world by themselves, as distinct from that of chemical forces, actions, and aggregations as these are from the mechanical ones of dynamic surface-geology, which produce and are embodied in visible and tangible masses through forces the most directly apparent and best understood; or as distinct as these are from the internal forces of geology and the masses of

continents and mountain formations with which they deal; or as distinct again as these are from the actions of gravity and the masses in the solar system; or, again, as these are from the unknown forces and conditions that regulate sidereal aggregations and movements. These various orders of molar and molecular sizes are limited in our powers of conception only by the needs of hypothesis in the representation of actual phenomena under visual forms and properties. Sir William Thomson has lately determined the probable sizes of chemical molecules from the phenomena of light and experiments relating to the law of the "conservation of force." According to these results, these sizes are such that if a drop of water were to be magnified to the size of the earth, its molecules, or parts dependent on the forces of chemical physics, would be seen to range from the size of a pea to that of a billiard-ball. But there is no reason to doubt that in every such molecule there are still subordinate parts and structures; or that, even in these parts, a still finer order of parts and structures exists, at least to the extent of assimilated growth and *simple* division. Mr. Darwin supposes such growths and divisions in the vital gemmules; but our author objects (p. 230) that, "to admit the power of spontaneous division and multiplication in such rudimentary structures seems a complete contradiction. The gemmules, by the hypothesis of Pangenesis, 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 *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." But this is to suppose what is not implied in the theory (nor properly even in the chemical theory of atoms), that the sizes of these bodies are any more constant or determinate than those of visible bodies of any order. It is the order only that is determinate; but within it there may be wide ranges of sizes. A billiard-ball may be divided into parts as small as a pea, or peas may be aggregated into masses as large as a billiard-ball, without going beyond the order of forces that produce both sizes. Our author himself says afterwards

and in another connection (p. 200), "It is possible that, in some minds, the notion may lurk that such powers are simpler and easier to understand, because the bodies they affect are so minute! This absurdity hardly bears stating. We can easily conceive a being so small that a gemmule would be to it as large as St. Paul's would be to us." This argument, however, is intended to discredit the theory on the ground that it does not tend to simplify matters, and that we must rest somewhere in "what the scholastics called 'substantial forms.'" But this criticism, to be just, ought to insist, not only that vital phenomena are due to "a special nature, a peculiar innate power and activity," but that chemical atoms only complicate the mysteries of science unnecessarily; that corpuscles and undulations only hide difficulties; and that we ought to explain very simply that crystalline bodies are produced by "polarity," and that the phenomena of light and vision are the effects of "luminosity." This kind of simplicity is not, however, the purpose which modern science has in view; and, consequently, our real knowledges, as well as our hypotheses, are much more complicated than were those of the schoolmen. It is not impossible that vital phenomena themselves include orders of forces as distinct as the lowest vital are from chemical phenomena. May not the contrast of merely vital or vegetative phenomena with those of *sensibility* be of such orders? But, in arriving at *sensibility*, we have reached the very elements out of which the conceptions of size and movement are constructed, — the elements of the tactual and visual constructions that are employed by such hypotheses. Can sensibility and the movements governed by it be derived directly by chemical synthesis from the forces of inorganic elements? It is probable, both from analogy and direct observation, that they cannot (though some of the believers in "spontaneous generation" think otherwise); or that they cannot, except by that great alchemic experiment which, employing all the influences of nature and all the ages of the world, has actually brought forth most if not all of the definite forms of life in the last and greatest work of creative power.

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