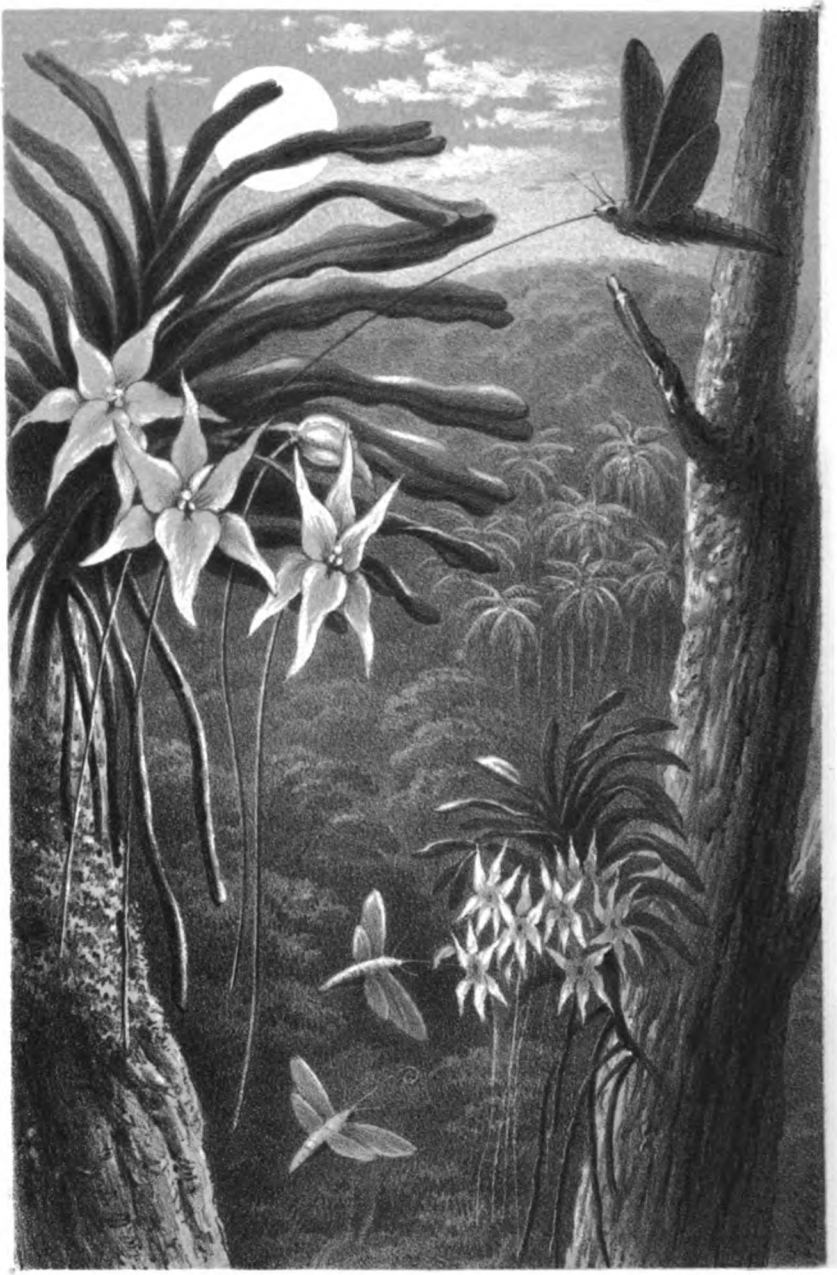

SPHINX MOTH FERTILIZING ANGRŒCUM SESQUIPEDALE IN THE FORESTS OF MADAGASCAR.

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I. CREATION BY LAW.

By Alfred R. Wallace, F.Z.S., F.R.G.S., &c.

Among the various criticisms that have appeared on Mr. Darwin's celebrated "Origin of Species," there is, perhaps, none that will appeal to so large a number of well educated and intelligent persons as that contained in the Duke of Argyll's "Reign of Law." The noble author represents the feelings and expresses the ideas of that large class who take a keen interest in the progress of Science in general, and especially that of Natural History, but have never themselves studied nature in detail, or acquired that personal knowledge of the structure of closely allied forms,—the wonderful gradations from species to species and from group to group, and the infinite variety of the phenomena of "variation" in organic beings,—which are absolutely necessary for a full appreciation of the facts and reasonings contained in Mr. Darwin's great work.

Nearly half of the Duke's book is devoted to an exposition of his idea of 'Creation by Law' and he expresses so clearly what are his difficulties and objections as regards the theory of "Natural Selection," that I think it advisable that they should be fairly answered, and that his own views should be shown to lead to conclusions as hard to accept as any which he imputes to Mr. Darwin.

The point on which the Duke of Argyll lays most stress is, that proofs of Mind everywhere meet us in Nature, and are more especially manifest wherever we find "contrivance" or "beauty." He maintains that this indicates the constant supervision and direct interference of the Creator, and cannot possibly be explained by the unassisted action of any combination of laws. Now Mr. Darwin's work has for its main object to show, that all the phenomena of living things,—all their wonderful organs and complicated structures, their infinite variety of form, size, and colour, their intricate and involved relations to each other,—may have been produced by

the action of a few general laws of the simplest kind, laws which are in most cases mere statements of admitted facts. The chief of these laws or facts are the following:—

1. *The Law of Multiplication in Geometrical Progression.*—All organized beings have enormous powers of multiplication. Even man, who increases slower than all other animals, could under favourable circumstances double his numbers every ten years, or a thousand-fold in a century. Most animals and plants could increase their numbers from ten to a thousand-fold every year.

2. *The Law of Limited Population.*—The number of living individuals of each species in any country, or in the whole globe, is practically stationary; whence it follows that the whole of this enormous increase must die off almost as fast as produced, except only those individuals for whom room is made by the death of parents. As a simple but striking example, take an oak forest. Every oak will drop annually thousands or millions of acorns, but till an old tree falls, not one of these millions can grow up into a tree. They must die at various stages of growth.

3. *The Law of Heredity, or likeness of offspring to their parents.*—This is a universal, but not an absolute law. All creatures resemble their parents in a high degree, and in the majority of cases very accurately; so that even individual peculiarities of whatever kind in the parents are almost always transmitted to some of the offspring.

4. *The Law of Variation.*—This is fully expressed by the lines:—

> "No being on this earthly ball,
> Is like another, all in all."

Offspring resemble their parents very much, but not wholly—each being possesses its individuality. This "variation" itself varies in amount, but it is always present, not only in the whole being, but in every part of every being. Every organ, every character, every feeling is individual; that is to say, *varies* from the same organ, character, or feeling in every other individual.

5. *The Law of unceasing change of Physical Conditions upon the Surface of the Earth.*—Geology shows us that this change has always gone on in times past, and we also know that it is now everywhere going on.

6. *The Equilibrium of Nature.*—When a species is well adapted to the conditions which environ it,—it flourishes; when imperfectly adapted it decays; when ill-adapted it becomes extinct. If *all* the conditions which determine an organism's well-being are taken into consideration, this statement can hardly be disputed.

This series of facts or laws are mere statements of what is the condition of nature. They are facts or inferences which are

generally known, generally admitted,—but in discussing the subject of the 'Origin of Species,'—as generally forgotten. It is from these universally admitted facts that the origin of all the varied forms of nature may be deduced by a logical chain of reasoning, which, however, is at every step verified and shown to be in strict accord with facts; and, at the same time, a host of curious facts which can by no other means be understood, are explained and accounted for. It is probable that these primary facts or laws are but results of the very nature of life, and of the essential properties of organized and unorganized matter. Mr. Herbert Spencer, in his "First Principles" and his "Biology" has, I think, made us able to understand how this may be; but at present we may accept these laws without going further back, and the question then is—whether the variety, the harmony, the contrivance, and the beauty we perceive in organic beings, can have been produced by the action of these laws alone, or whether we are required to believe in the incessant interference and direct action of the mind and will of the Creator. It is simply a question of how the Creator has worked. The Duke maintains, that he has personally applied general laws to produce effects which those laws are not in themselves capable of producing; that the universe alone, with all its laws intact, would be a sort of chaos, without variety, without harmony, without design, without beauty; that there is not (and therefore we may presume that there could not be) any self-developing power in the universe. I believe, on the contrary, that the universe is so constituted as to be self-regulating; that as long as it contains Life, the forms under which that life is manifested have an inherent power of adjustment to each other and to surrounding nature; and that this adjustment necessarily leads to the greatest possible amount of variety and beauty and enjoyment, because it does depend on general laws, and not on a continual supervision and re-arrangement of details. As a matter of feeling and religion, I hold this to be a far higher conception of the Creator and of the Universe than that which I must call the "continual interference," hypothesis; but it is not a question to be decided by our feelings or convictions, it is a question of facts and of reason. Could the change, which Geology shows us has ever taken place in the forms of life, have been produced by general laws, or does it imperatively require the incessant supervision of a creative mind? This is the question for us to consider, and our opponents have the difficult task of proving their negative, if we show that there are both facts and analogies in our favour.

Mr. Darwin has laid himself open to much misconception, and has given to his opponents a powerful weapon by his continual use of metaphor in describing the wonderful co-adaptations of organic beings.

"It is curious," says the Duke of Argyll, "to observe the language which this most advanced disciple of pure naturalism instinctively uses, when he has to describe the complicated structure of this curious order of plants (the Orchids). 'Caution in ascribing intentions to nature,' does not seem to occur to him as possible. Intention is the one thing which he does see, and which when he does not see, he seeks for diligently until he finds it. He exhausts every form of words and of illustration by which intention or mental purpose can be described. 'Contrivance'—'curious contrivance'—'beautiful contrivance,'—these are expressions which occur over and over again. Here is one sentence describing the parts of a particular species; 'the Labellum is developed into a long nectary, *in order* to attract Lepidoptera, and we shall presently give reason for suspecting that the nectar is *purposely* so lodged, that it can be sucked only slowly *in order* to give time for the curious chemical quality of the viscid matter setting hard and dry.'" Many other examples of similar expressions are quoted by the Duke, who maintains that no explanation of these "contrivances" has been or can be given, except on the supposition of a personal contriver, specially arranging the details of each case, although causing them to be produced by the ordinary processes of growth and reproduction.

Now there is a difficulty in this view of the origin of the structure of Orchids which the Duke does not allude to. The majority of flowering plants are fertilized, either without the agency of insects or, when insects are required, without any very important modification of the structure of the flower. It is evident, therefore, that flowers might have been formed as varied, fantastic, and beautiful as the Orchids and yet have been fertilized by insects, in the same manner as Violets, or Clover, or Primroses or a thousand other flowers. The strange springs and traps and pitfalls found in the flowers of Orchids cannot be necessary *per se*, since exactly the same end is gained in ten thousand other flowers which do not possess them. Is it not then an extraordinary idea to imagine the Creator of the Universe *contriving* the various complicated parts of these flowers as a mechanic might contrive an ingenious toy or a difficult puzzle? Is it not a more worthy conception that they are some of the results of those general laws which were so co-ordinated at the first introduction of life upon the earth as to result necessarily in the utmost possible development of varied forms?

But let us take one of the simpler cases adduced and see if our general laws are unable to account for it.

"There is a Madagascar Orchis—the Angræcum sesquipedale—with an immensely long and deep nectary. How did such an extraordinary organ come to be developed? Mr. Darwin's explana-

tion is this. The pollen of this flower can only be removed by the proboscis of some very large moths trying to get at the nectar at the bottom of the vessel. The moths with the longest proboscis would do this most effectually; they would be rewarded for their long noses by getting the most nectar; whilst on the other hand, the flowers with the deepest nectaries would be the best fertilized by the largest moths preferring them. Consequently, the deepest nectaried Orchids and the longest nosed moths would each confer on the other a great advantage in the 'battle of life.' This would tend to their respective perpetuation and to the constant lengthening of nectar and noses." The Duke of Argyll then quotes Darwin's diffident statement "that we can thus *partially* understand how this astonishing nectary was produced," and says it is indeed but a *partial* understanding,—but he does not show what point the explanation given fails to meet. I maintain, on the contrary, that the laws of multiplication, variation, and survival of the fittest, already referred to, would under certain conditions *necessarily* lead to the production of this extraordinary nectary. Let it be remembered that what we have to account for is only the unusual length of this organ. A nectary is found in many orders of plants and is especially common in the Orchids, but in this one case only is it more than a foot long. How did this arise? We begin with the fact, proved experimentally by Mr. Darwin, that moths do visit Orchids, do thrust their spiral trunks into the nectaries, and do fertilize them by carrying the pollinia of one flower to the stigma of another. He has further explained the exact mechanism by which this is effected, and the Duke of Argyll admits the accuracy of his observations. In our British species, such as Orchis pyramidalis, it is not necessary that there should be any exact adjustment between the length of the nectary and that of the proboscis of the insect, and thus a number of insects of various sizes are found to carry away the pollinia and aid in the fertilization. In the Angræcum sesquipedale, however, it is necessary that the proboscis should be forced down into a particular part of the flower, and this would only be done by a large moth straining to drain the nectar from the bottom of the long tube.* Now let us start from the time when the nectary was only half its present length or about six inches, and was chiefly fertilized by a species of moth which appeared at the time of the plant's flowering, and whose proboscis was of the same length. Among the millions of flowers of the Angræcum produced every year some would always be shorter than the average, some longer. The former, owing to the structure of the flower, would not get fertilized, because the moths could get all the nectar without forcing their trunks down to the very base.

* It is a peculiarity of this species that the nectar only occupies a depth of one or two inches at the bottom of the nectary.

The latter would be well fertilized, and the longest would on the average be the best fertilized of all. By this process alone the average length of the nectary would annually increase, because, the short ones being sterile and the long ones having abundant offspring, exactly the same effect would be produced as if a gardener destroyed the short ones and sowed the seed of the long ones only; and this we know by experience would produce a regular increase of length, since it is this very process which has increased the size and changed the form of our cultivated fruits and flowers.

But this would lead in time to such an increased length of the nectary that many of the moths could only just reach the surface of the nectar, and only the few with exceptionally long trunks be able to suck up a considerable portion.

This would cause many moths to neglect these flowers because they could not get a satisfying supply of nectar, and if these were the only moths in the country the flowers would undoubtedly suffer and the further growth of the nectary be checked by exactly the same process which had led to its increase. But there are an immense variety of moths of various lengths of proboscis, and as the nectary became longer other and larger species would become the fertilizers, and would carry on the process till the largest moths became the sole agents. Now, if not before, the moth would also be affected, for those with the longest probosces would get most food, would be the strongest and most vigorous, would visit and fertilize the greatest number of flowers, and would leave the largest number of descendants. The flowers most completely fertilized by these moths being those which had the longest nectaries, there would in each generation be on the average an increase in the length of the nectaries, and also an average increase in the length of the proboscis of the moths, and this would be a *necessary result* from the fact that nature ever fluctuates about a mean, or that in every generation there would be flowers with longer and shorter nectaries, and moths with longer and shorter probosces than the average. No doubt there are a hundred causes that might have checked this process before it had reached the point of development at which we find it. If, for instance, the variation in the quantity of nectar had been at any stage greater than the variation in the length of the nectary, then smaller moths could have reached it and have effected the fertilization. Or if the growth of the probosces of the moths had from other causes increased quicker than that of the nectary, or if the increased length of proboscis had been injurious to them in any way, or if the species of moth with the longest proboscis had become much diminished by some enemy or other unfavourable conditions, then in any of these cases the shorter nectaried flowers which would have attracted and could have been fertilized by the smaller kinds of

moths would have had the advantage. And checks of a similar nature to these no doubt have acted in other parts of the world, and have prevented such an extraordinary development of nectary as has been produced by favourable conditions in Madagascar only and in one single species of Orchid. I may here mention that some of the large Sphinx moths of the tropics have probosces nearly as long as the nectary of Angræcum sesquipedale.* Now, instead of this beautiful self-acting adjustment, the Duke of Argyll's theory is, that the Creator of the Universe by a direct act of his Almighty power so disposed the natural forces influencing the growth of this one species of plant as to cause its nectary to increase to this enormous length, and at the same time by an equally special act determined the flow of nourishment in the organization of the moth so as to cause its proboscis to increase in exactly the same proportion, having previously so constructed the Angræcum that it could only be maintained in existence by the agency of this moth. But what proof is given or suggested that this was the mode by which the adjustment took place? None whatever, except a feeling that there is an adjustment of a delicate kind and an inability to see how known causes could have produced such an adjustment. I believe I have shown, however, that such an adjustment is not only possible but inevitable, unless at some point or other we deny the action of those simple laws which we have already admitted to be expressions of existing facts.

It is difficult to find anything like parallel cases in inorganic nature, but that of a river may perhaps illustrate the subject in some degree. Let us suppose a person totally ignorant of Modern Geology to study carefully a great River System. He finds in the lower part a deep broad channel filled to the brim, flowing slowly through a flat country and carrying out to the sea a quantity of fine sediment. Higher up it branches into a number of smaller channels flowing alternately through flat valleys and between high banks; sometimes he finds a deep rocky bed with perpendicular walls carrying the water through a chain of hills; where the stream is narrow he finds it deep, where wide shallow. Further up still he comes to a mountainous region with hundreds of streams and rivulets each with its tributary rills and gullies collecting the water from every square mile of surface, and every channel adapted

* I have carefully measured the proboscis of a specimen of *Macrosila cluentius* from South America in the collection of the British Museum, and find it to be nine inches and a quarter long! One from tropical Africa (*Macrosila morgani*) is seven inches and a half. A species having a proboscis two or three inches longer could reach the nectar in the largest flowers of *Angræcum sesquipedale*, whose nectaries vary in length from ten to fourteen inches. That such a moth exists in Madagascar may be safely predicted; and naturalists who visit that island should search for it with as much confidence as astronomers searched for the planet Neptune,—and they will be equally successful!

to the water that it has to carry. He finds that the bed of every branch and stream and rivulet has a steeper and steeper slope as it approaches its sources, and is thus enabled to carry off the water from heavy rains and to bear away the stones and pebbles and gravel that would otherwise block up its course. In every part of this system he would see exact adaptation of means to an end. He would say that this system of channels must have been designed, it answers its purpose so effectually. Nothing but a mind could have so exactly adapted the slopes of the channels, their capacity, and frequency to the nature of the soil and the quantity of the rainfall. Again, he would see special adaptation to the wants of man in broad quiet navigable rivers through fertile alluvial plains that would support a large population, while the rocky streams and mountain torrents were confined to those sterile regions suitable only for a small population of shepherds and herdsmen. He would listen with incredulity to the Geologist who assured him that the adaptation and adjustment he so admired was an inevitable result of the action of general laws. That the rains and rivers, aided by subterranean forces, had modelled the country, had formed the hills and valleys, had scooped out the river beds and levelled the plains;—and it would only be after much patient observation and study, after having watched the minute changes produced year by year and multiplying them by thousands and ten thousands, after visiting the various regions of the earth and seeing the changes everywhere going on, and the unmistakeable signs of greater changes in past times,—that he could be made to understand that the surface of the earth, however beautiful and harmonious it may appear, is strictly due in every detail to the action of forces which are demonstrably self-adjusting.

Moreover, when he had sufficiently extended his inquiries, he would find that every evil effect which he would imagine must be the result of non-adjustment does somewhere or other occur, only it is not always evil. Looking on a fertile valley he would say—"If the channel of this river was not well adjusted, if for a few miles it sloped the wrong way, the water could not escape, and all this fertile valley full of human beings would become a waste of waters." Well, there are hundreds of such cases. Every lake is a valley "wasted by water," and in some cases (as the Dead Sea) it is a positive evil, a blot upon the harmony and adaptation of the surface of the earth. Again, he might say—"If rain did not fall here, but the clouds passed over us to some other regions, this fair valley would be a desert." And there are such deserts over a large part of the earth, which abundant rains would convert into pleasant dwelling-places for man. Or he might observe some great navigable river, and reflect how easily rocks or a steeper channel in places might render it useless to man;—and a little inquiry would show

him hundreds of rivers in every part of the world which are thus rendered useless for navigation.

Exactly the same thing occurs in organic nature. We see some one wonderful case of adjustment, some unusual development of an organ, but we pass over the hundreds of cases in which that adjustment and development do not occur. No doubt when one adjustment is absent another takes its place, because no organism can continue to exist that is not adjusted to its environment; and unceasing variation with unlimited powers of multiplication, in most cases, furnish the means of self-adjustment. The world is so constituted, that by the action of general laws there is produced the greatest possible variety of surface and of climate; and by the action of laws equally general, the greatest possible variety of organisms have been produced adapted to the varied conditions of every part of the earth. The Duke of Argyll would probably himself admit that the varied surface of the earth, the plains and valleys, the hills and mountains, the deserts and volcanoes, the winds and currents, the seas and lakes and rivers, and the various climates of the earth, are all the results of general laws acting and re-acting during countless ages; and that the Creator does not appear to guide and control the action of these laws — here determining the height of a mountain, there altering the channel of a river—here making the rains more abundant, there changing the direction of a current. He would probably admit that the forces of inorganic nature are self-adjusting, and that the result necessarily fluctuates about a given mean condition (which is itself slowly changing), while within certain limits the greatest possible amount of variety is produced. If then a "contriving mind" is not necessary at every step of the process of change eternally going on in the inorganic world, why are we required to believe in the continual action of such a mind in the region of organic nature? True, the laws at work are more complex, the adjustments more delicate, the appearance of special adaptation more remarkable; but why should we measure the creative mind by our own? Why should we suppose the machine too complicated to have been designed by the Creator so complete, that it would necessarily work out harmonious results? The theory of "continual interference" is a limitation of the Creator's power. It assumes that he could not work by pure law in the organic as he has done in the inorganic world; it assumes that he could not foresee the consequences of the laws of matter and mind combined—that results would continually arise which are contrary to what is best, and that he has to change what would otherwise be the course of nature in order to produce that beauty and variety and harmony, which even we, with our limited intellects, can conceive to be the result of self-adjustment in a universe governed by unvarying law. If we could not conceive the world

of nature to be self-adjusting and capable of endless development, it would even then be an unworthy idea of a Creator to impute the incapacity of our minds to him; but when many human minds can conceive and can even trace out in detail some of the adaptations in nature as the necessary results of unvarying law, it seems strange that in the interests of religion any one should seek to prove that the System of Nature instead of being above, is far below our highest conceptions of it. I, for one, cannot believe that the world would come to chaos if left to Law alone. I cannot believe that there is in it no inherent power of developing beauty or variety, and that the direct action of the Deity is required to produce each spot or streak on every insect, each detail of structure in every one of the millions of organisms that live or have lived upon the earth. For it is impossible to draw a line. If any modifications of structure could be the result of law, why not all? If some self-adaptations could arise, why not others? If any varieties of colour, why not all the variety we see? No attempt is made to explain this except by reference to the fact that "purpose" and "contrivance" are everywhere visible, and by the illogical deduction that they could only have arisen from the direct action of some mind, because the direct action of our minds produces similar "contrivances;" but it is forgotten that adaptation, however produced, must have the appearance of design. The channel of a river looks as if made *for* the river although it is made *by* it; the fine layers and beds in a deposit of sand often look as if they had been sorted and sifted and levelled designedly; the sides and angles of a crystal exactly resemble similar forms designed by man; but we do not therefore conclude that these effects have, in each individual case, required the directing action of a creative mind, or see any difficulty in their being produced by natural Law.

Let us, however, leave this general argument for a while, and turn to another special case which our author appeals to as conclusive against Mr. Darwin's views. "Beauty" is as great a stumbling-block to the Duke of Argyll as "contrivance." He cannot conceive a system of the Universe so perfect as necessarily to develope every form of Beauty, but supposes that when anything specially beautiful occurs, it is a step beyond what that system could have produced, something which the Creator has added for his own delectation.

Speaking of the Humming Birds, the Duke of Argyll says: "In the first place, it is to be observed of the whole group that there is no connection which can be traced or conceived between the splendour of the humming birds and any function essential to their life. If there were any such connection, that splendour could not be confined, as it almost exclusively is, to only one sex. The

female birds are of course not placed at any disadvantage in the struggle for existence by their more sombre colouring." And after describing the various ornaments of these birds, he says: "Mere ornament and variety of form, and these for their own sake, is the only principle or rule with reference to which Creative Power seems to have worked in these wonderful and beautiful birds. . . . . A crest of topaz is no better in the struggle for existence than a crest of sapphire. A frill ending in spangles of the emerald is no better in the battle of life than a frill ending in spangles of the ruby. A tail is not affected for the purposes of flight, whether its marginal or its central feathers are decorated with white. . . . . Mere beauty and mere variety for their own sake, are objects which we ourselves seek when we can make the Forces of Nature subordinate to the attainment of them. There seems to be no conceivable reason why we should doubt or question that these are ends and aims also in the forms given to living organisms."*

Here the statement that "no connection can be conceived between the splendour of the humming birds and any function essential to their life;" is met by the fact that Mr. Darwin has not only conceived but has shown, both by observation and reasoning, how beauty of colour and form may have a direct influence on the most important of all the functions of life, that of reproduction. In the variations to which birds are subject, any more brilliant colour than usual would be attractive to the females, and would lead to the individuals so adorned leaving more than the average number of offspring. Experiment and observation have shown that this kind of sexual selection does actually take place, and the laws of inheritance would necessarily lead to the further development of any individual peculiarity that was attractive, and thus the splendour of the humming birds is directly connected with their very existence. It is true that "a crest of topaz may be no better than a crest of sapphire," but either of these may be much better than no crest at all; and the different conditions under which the parent form must have existed in different parts of its range, will have determined different variations of tint, either of which were advantageous. The reason why female birds are not adorned with equally brilliant plumes is sufficiently clear; they would be injurious by rendering their possessors too conspicuous during incubation. Survival of the fittest has therefore favoured the development of those dark green tints on the upper surface of so many female humming birds, which are most conducive to their protection while the important functions of hatching and rearing the young are being carried on. Keeping in mind the laws of multiplication,

* 'Reign of Law,' p. 248.

variation, and survival of the fittest which are for ever in action, these varied developments of beauty and harmonious adjustments to conditions, are not only conceivable but demonstrable results.

The Duke's argument is solely founded on the supposed analogy of the Creator's mind to ours as regards the love of Beauty for its own sake; but if this analogy is to be trusted, then there ought to be no natural objects which are disagreeable or ungraceful in our eyes. And yet it is undoubtedly the fact that there are many such. Just as surely as the Horse and Deer are beautiful and graceful, the Elephant, Rhinoceros, and Camel are the reverse. The majority of Monkeys and Apes are not beautiful; the majority of Birds have no beauty of colour; a vast number of Insects and Reptiles are positively ugly. Now, if the Creator's mind is like ours, whence this ugliness? It is useless to say "that is a mystery we cannot explain," because we have attempted to explain one-half of creation by a method that will not apply to the other half. We know that a man with the highest taste and with unlimited wealth practically does abolish all ungraceful and disagreeable forms and colours from his own domains. If the beauty of creation is to be explained by the Creator's love of beauty, we are bound to ask why he has not banished deformity from the earth, as the wealthy and enlightened man does from his estate; and if we can get no satisfactory answer, we shall do well to reject the explanation offered. Again, in the case of flowers, which are always especially referred to as the surest evidence of beauty being an end of itself in creation, the whole of the facts are never fairly met. At least half the plants in the world have not bright-coloured or beautiful flowers, and Mr. Darwin has lately arrived at the wonderful generalization that flowers have become beautiful solely to attract insects to assist in their fertilization. He adds, "I have come to this conclusion from finding it an invariable rule that when a flower is fertilized by the wind it never has a gaily-coloured corolla."* Here is a most wonderful case of beauty being *useful* when it might be least expected. But much more is proved; for when beauty is of no use to the plant it is not given. It cannot be imagined to do any harm. It is simply not necessary, and is therefore withheld! We ought surely to have been told how this fact is consistent with beauty being "an end in itself," and with the statement of its being given to natural objects "for its own sake."

Let us now consider another of the Duke's objections which he thus sets forth:—

"Mr. Darwin does not pretend to have discovered any law or rule according to which new Forms have been born from old Forms. He does not hold that outward conditions, however changed, are

* 'Origin of Species,' 4th ed., p. 239.

sufficient to account for them. . . . . His theory seems to be far better than a mere theory—to be an established scientific truth—in so far as it accounts, in part at least, for the success and establishment and spread of new Forms *when they have arisen.* But it does not even suggest the law under which, or by or according to which, such new Forms are introduced. Natural Selection can do nothing, except with the materials presented to its hands. It cannot select except among the things open to selection. . . . Strictly speaking, therefore, Mr. Darwin's theory is not a theory on the Origin of Species at all, but only a theory on the causes which lead to the relative success or failure of such new forms as may be born into the world."*

In this and many other passages in his work the Duke of Argyll sets forth his idea of Creation as a "Creation by birth," but maintains that each birth of a new form from parents differing from itself, has been produced by a special interference of the Creator in order to direct the process of development into certain channels; that each new species is in fact a "special creation," although brought into existence through the ordinary laws of reproduction. He maintains therefore that the laws of multiplication and variation cannot furnish the right kinds of materials at the right times for natural selection to work on. I believe that it can be logically proved from the six axiomatic laws before laid down, that such materials would be furnished; but I prefer to show that there are abundance of *facts* which prove the same thing.

The experience of all cultivators of plants and breeders of animals shows, that when a sufficient number of individuals are produced variations of any required kind can always be met with. On this depends the possibility of obtaining breeds, races, and fixed varieties of animals and plants, and it is found that any one form of variation may be accumulated by selection without materially affecting the other characters of the species; each *seems* to vary in the one required direction only. For example, in turnips, radishes, potatoes, and carrots, the root or tuber varies in size, colour, form, and flavour, while the foliage and flowers seem to remain almost stationary; in the cabbage and lettuce, on the contrary, the foliage can be modified into various forms and modes of growth, the root, flower, and fruit remaining little altered; in the cauliflower and brocoli the flower heads vary; in the garden pea the pod only changes. We get innumerable forms of fruit in the apple and pear, while the leaves and flowers remain undistinguishable; the same occurs in the gooseberry and garden currant. Directly however (in the very same genus) we want the flower to vary in the Ribes sanguineum, it does so, although mere cultivation for hundreds of

* 'Reign of Law,' p. 230.

years has not produced marked differences in the flowers of Ribes grossularia. When fashion demands any particular change in the form, or size, or colour of a flower, sufficient variation always occurs in the right direction, as is shown by our roses, auriculas, and geraniums; when, as recently, ornamental leaves come into fashion sufficient variation is found to meet the demand, and we have zoned pelargoniums and variegated ivy, and it is discovered that a host of our commonest shrubs and herbaceous plants have taken to vary in this direction just when we want them to do so! This rapid variation is not confined to old and well-known plants subjected for a long series of generations to cultivation, but the Sikhim Rhododendrons, the Fuchsias and Calceolarias from the Andes, and the Pelargoniums from the Cape are equally accommodating, and vary just when and where and how we require them.

Turning to animals we find equally striking examples. If we want any special quality in any animal we have only to breed it in sufficient quantities and watch carefully, and the required variety is *always* found and can be increased to almost any desired extent. In Sheep we get flesh, fat, and wool; in Cows, milk; in Horses, colour, strength, size and speed; in Poultry, we have got almost any variety of colour, curious modifications of plumage, and the capacity of perpetual egg-laying. In Pigeons we have a still more remarkable proof of the universality of variation, for it has been at one time or another the fancy of breeders to change the form of every part of these birds, and they have never found the required variations absent. The form, size, and shape of bill and feet, have been changed to such a degree as is found only in distinct genera of wild birds; the number of tail feathers has been increased, a character which is generally one of the most permanent nature and is of high importance in the classification of birds; and the size, the colour, and the habits have been also changed to a marvellous extent. In Dogs, the degree of modification and the facility with which it is effected is almost equally apparent. Look at the constant amount of variation in opposite directions that must have been going on to develope the poodle and the greyhound from the same original stock! Instincts, habits, intelligence, size, speed, form, and colour, have always varied as needed to produce the races which the wants or fancies or passions of men may have led them to desire. Whether they wanted a bull-dog to torture another animal, a greyhound to catch a hare, or a bloodhound to hunt down their oppressed fellow-creatures, the required variations have always appeared.

Now this great mass of facts, of which a mere sketch has been here given, are fully accounted for by the "Law of Variation" as laid down at the commencement of this paper. Universal variability,—small in amount but in every direction, ever fluctuating about a mean condition until made to advance in a given direction by

"selection" natural or artificial,—is the simple basis for the indefinite modification of the forms of life;—partial, unbalanced, and consequently unstable modifications being produced by man, while those developed under the unrestrained action of natural laws, are at every step self-adjusted to external conditions by the dying out of all unadjusted forms, and are therefore stable and comparatively permanent. To be consistent in his views the Duke of Argyll must maintain that every one of the variations that have rendered possible the changes produced by man, have been determined at the right time and place by the will of the Creator. Every race produced by the florist or the breeder, the dog or the pigeon fancier, the ratcatcher, the sporting man, or the slave-hunter, must have been provided for by varieties occurring when wanted, and as these variations were never withheld it would appear as if the sanction of an allwise and all-powerful Being had been given to that which the highest human minds consider to be trivial, mean, or debasing.

This appears to be a complete answer to the theory, that variation sufficient in amount to be accumulated in a given direction must be the direct act of the creative mind, but it is also sufficiently condemned by being so entirely unnecessary. The facility with which man obtains new races, depends chiefly upon the number of individuals he can procure to select from. When hundreds of florists or breeders are all aiming at the same object the work of change goes on rapidly. But a common species in nature contains a thousandfold more individuals than any domestic race, and survival of the fittest must unerringly preserve all that vary in the right direction not only in obvious characters but in minute details, not only in external but in internal organs; so that if the materials are sufficient for the needs of man, there can be no want of them to fulfil the grand purpose of keeping up a supply of modified organisms exactly adapted to the changed conditions that are always occurring in the inorganic world.

Having now, I believe, fairly answered the chief objections of the Duke of Argyll, I proceed to notice one or two of those adduced in an able and argumentative essay on the "Origin of Species" in the July number of the 'North British Review.' The writer first attempts to prove that there are strict limits to variation. When we begin to select variations in any one direction, the process is comparatively rapid, but after a considerable amount of change has been effected it becomes slower and slower till at length its limits are reached, and no care in breeding and selection can produce any further advance. The race-horse is chosen as an example. It is admitted that, with any ordinary lot of horses to begin with, careful selection would in a few years make a great improvement, and in a comparatively short time the standard of our best racers might be reached. But that standard has

not for many years been materially raised, although unlimited wealth and energy are expended in the attempt. This is held to prove that there are definite limits to variation in any special direction, and that we have no reason to suppose that mere time, and the selective process being carried on by natural law, could make any material difference. But the writer does not perceive that this argument fails to meet the real question, which is, not whether indefinite and unlimited change in any or all directions is possible, but whether such differences as do occur in nature could have been produced by the accumulation of variations by selection. In the matter of speed a limit of a definite kind as regards land animals does exist in nature. All the swiftest animals —deer, antelopes, hares, foxes, lions, leopards, horses, zebras, and many others, have reached very nearly the same degree of speed. Although the swiftest of each must have been for ages preserved, and the slowest must have perished, we have no reason to believe there is any advance of speed. The possible limits under existing conditions, and perhaps under possible terrestrial conditions, has been long ago reached. In cases, however, where this limit had not been so nearly reached as in the horse, we have been enabled to make a more marked advance and to produce a greater difference of form. The wild dog is an animal that hunts much in company, and trusts more to endurance than to speed. Man has produced the greyhound, which differs much more from the wolf or the dingo than the racer does from the wild Arabian.

Again, it is objected that the Pouter or the Fan-tail pigeon cannot be further developed in the same direction. Variation seems to have reached its limits in these birds. But so it has in nature. The Fan-tail has not only more tail feathers than any of the three hundred and forty existing species of pigeons, but more than any of the eight thousand known species of birds. There is, of course, some limit to the number of feathers of which a tail useful for flight can consist, and in the Fan-tail we have probably reached that limit. Many birds have the œsophagus or the skin of the neck more or less dilatable, but in no known bird is it so dilatable as in the Pouter pigeon. Here again the possible limit, compatible with a healthy existence, has probably been reached. In like manner the differences in the size and form of the beak in the various breeds of the domestic Pigeon, is greater than that between the extreme forms of beak in the various genera and subfamilies of the whole Pigeon tribe. From these facts, and many others of the same nature, we may fairly infer, that if rigid selection were applied to any organ, we could in a comparatively short time produce a much greater amount of change than that which occurs between species and species in a state of nature, since the differences which we do produce are often comparable with those which exist

between distinct genera or distinct families. The facts adduced by the writer of this article, of the definite limits to variability in certain directions in domesticated animals, are no objection whatever to the view that all the modifications which exist in nature have been produced by the accumulation by natural selection of small and useful variations, since those very modifications have equally definite and very similar limits.

To another of this writer's objections — that by Professor Thomson's calculations the sun can only have existed in a solid state 500 millions of years, and that therefore *time* would not suffice for the slow process of development of all living organisms— it is hardly necessary to reply, as it cannot be seriously contended, either that this calculation has any claims to even approximate accuracy, or that the process of change and development may not have been sufficiently rapid to have occurred within that period. His objection to the Classification argument is, however, more plausible. The uncertainty of opinion among Naturalists as to which are species and which varieties, is one of Mr. Darwin's very strong arguments that these two names cannot belong to things quite distinct in nature and origin. The Reviewer says that this argument is of no weight, because the works of man present exactly the same phenomena, and he instances patent inventions, and the excessive difficulty of determining whether they are new or old. I accept the analogy, and maintain that it is all in favour of Mr. Darwin's views. For are not all inventions of the same kind directly affiliated to a common ancestor. Are not improved Steam Engines or Clocks the lineal descendants of some existing Steam Engine or Clock? Is there ever a new Creation in Art or Science any more than in Nature? Did ever patentee absolutely originate any complete and entire invention, no portion of which was derived from anything that had been made or described before? It is therefore clear that the difficulty of distinguishing the various classes of inventions which claim to be new is of the same nature as the difficulty of distinguishing varieties and species, because neither are absolute new creations, but both are alike descendants of pre-existing forms, from which and from each other they differ by varying and often imperceptible degrees. It appears then, that however plausible this writer's objections may seem, whenever he descends from generalities to any specific statement, his supposed difficulties turn out to be in reality strongly confirmatory of Mr. Darwin's view.

I cannot conclude this paper without expressing my admiration of the manner in which many subjects are treated in the "Reign of Law." With the definition and limitation of the term "Supernatural," I cordially agree. The exposition of the mechanism of flight is in every respect admirable; and the views on the Political

and Social aspects of the Free Labour question are calculated to do much good, and to draw attention to a subject of the highest importance. The want of equal success in treating the question of the Origin of Species, is no doubt due to the excessively varied and complex nature of the phenomena presented by organized beings. Fully to grasp what is involved in that question demands a knowledge of details, which it requires years of study to amass; and without such knowledge the acutest and most comprehensive intellect will not suffice to solve so intricate a problem.

II. INTERNATIONAL EXHIBITIONS.

By Fred. Chas. Danvers, M.S.E.

At the close of another grand International Exhibition we may well pause for a while and consider how far these great displays of the works of industry have fulfilled the objects for which they were first established. The thirteenth Paris Industrial Exhibition, and the second International collection of works of art and industry which has been held in that city, is now within a few days of its termination; and we may, therefore, for all practical purposes, speak of it as a thing of the past. Whatever articles of exhibition it may have contained that were considered especially deserving of remark have long since been reported on, and the Exhibitors have been awarded such prizes as the respective juries have thought fit to recommend. The building will yet remain open for a short time longer, and then the work of removal and demolition will speedily commence.

Before making any special allusion to the Paris Exhibition, it is our present intention to take a hasty glance at the origin and growth of Exhibitions generally, and the measures which preceded the first International Exhibition. We are indebted for much of our information on this subject to a Report on the Paris Exhibition, drawn up for the Society of Arts by M. Digby Wyatt, Esq., in 1849; and, with reference to Exhibitions in England, to the Official Catalogue of the International Exhibition of London, published in 1862.

Industrial Exhibitions in their early youth may have been content with a pedlar's pack, the travelling show-van, or a booth at a fair; but as soon as they gave up their gipsy life they began as national displays. It was long before the growing free-trade spirit of the age allowed them to become international, although museums did occasionally dabble in the products of foreign industry, and a catalogue of curiosities exhibited at the public theatre of Leyden, in 1699, gives an amusing account of one of these early Exhibitions.