

THE DARWINIAN THEORY
AND
THE LAW OF THE MIGRATION OF
ORGANISMS.

TRANSLATED FROM THE GERMAN OF

MORITZ WAGNER,

HONORARY PROFESSOR AT THE LUDWIG MAXIMILIAN UNIVERSITY OF MUNICH, AND
MEMBER EXTRAORDINARY OF THE ROYAL BAVARIAN ACADEMY OF SCIENCES.

BY

JAMES L. LAIRD,

ASSISTANT-CONSERVATOR OF FORESTS, PANJAB.

LONDON:
EDWARD STANFORD, 6 AND 7, CHARING CROSS, S.W.

1873.

Vignaud
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P R E F A C E.

IN a treatise which I had the honour to read before the Assembly of the Royal Academy of Sciences at Munich on the 2nd March, 1868, I endeavoured to prove the law of the migration of organisms, which I have more clearly and minutely demonstrated in the present work. Like all natural laws or causes of phenomena, this law is remarkable for its simplicity, for it is based on the two most powerful impulses of all living beings, *viz.* self-preservation and reproduction. The migration of organisms is a necessary consequence of these impulses, and is the first incentive to numerous variations.

The encouragement I have since received from many able naturalists induces me to publish this essay in the present form, or somewhat more in detail than the academical lecture; I have, however, confined myself to citing such facts from animal and vegetable geography as are essential to the question, and furnish, besides, the most important material for the theory of transmutation advanced by Charles Darwin.

Of the many letters I received in consequence of this lecture, none afforded me greater pleasure than one from the celebrated author, whose work on the 'Origin of Species' is the beginning of a new epoch, and for whom, as one of the greatest thinkers and naturalists of the present century, I entertain a regard sincere as it is profound.

Darwin's views appear to coincide on most points with those expressed in the present pamphlet. With extreme modesty he writes that from insufficient knowledge of many facts here communicated, he had been unable in his work to make proper use of the geographical distribution of plants and animals; kindly adding, that my theory of migration had set aside many difficulties and objections advanced against his theory of transmutation, in a manner which had never before occurred even to himself.

On one—certainly very important—point only is Darwin disposed to differ from me, *viz.* as to whether migration (that is to say, the constant tendency of individuals to wander from the station of their species, and by means of colonization to find better conditions of life for themselves and their descendants) is merely advantageous, or absolutely necessary for the formation of races and species.

The difference of opinion existing between Darwin

and myself on so important a point has induced me to treat it more fully at the end of this work. Perhaps that generous British naturalist, who is always open to conviction, after calmly weighing my reasons and data, may yet be induced to modify his opinions.

The migration of organisms and their colonisation are, according to my conviction, a necessary condition of natural selection. The former confirm the latter, set aside the most important objections which have been raised to the theory, and render the whole natural process of the formation of species much clearer than was previously the case.

Since the commencement of civilization the migration of animals and plants, and with it the capability of variation and development by natural selection, has become more and more limited; in fact, it must at last entirely cease and give place to artificial selection.

This necessary inference—which may serve to quiet many a systematic and zealous collector of species—gives to the law of migration a far greater importance than would otherwise be the case. Its application, especially to the development of the human race from the earliest ages of civilization, is certainly capable of much greater amplification than is aimed at in this treatise. This I purpose reserving for a future work.

Scruples and objections will not be wanting. These,

however, can never prove detrimental to science, for they invariably incite to fresh investigation, and often to fruitful controversy. And to the naturalist who does not seek the gratification of self, but is guided by an honest desire to attain as nearly as possible to a correct knowledge of causes, genuine scruples against his theory ought not to be unwelcome. Like philosophy, natural history has one great aim, the simple truth, such as it appears to the calm investigation of our reason, not as prescribed by tradition and fixed dogmas; and truth must ever remain the sole basis of our faith.

THE AUTHOR.

MUNICH, July, 1868.

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To ascertain the causes or laws which have given rise in the past and present of our planet to the multitudinous forms of organic beings, was rightly designated by Alphonse de Candolle the greatest problem in the natural history of the nineteenth century.

At the same time that gifted botanist submitted the following significant questions: "How is the development of both organic kingdoms in the course of thousands of years regulated? How do their numerous varieties, which through physical and geological causes from time to time disappear, arise and succeed each other? Are the successive creations links of the same chain, or are they, independent of each other, the results of separate acts of creation? Under what conditions and relations did these forms succeed each other? What was the history of the two organic kingdoms up to the present epoch?"

The learned author of the 'Géographie botanique raisonnée,' in pointing out these problems, the solution of which he left to a future generation, revealed a truly prophetic instinct. A few years later his inquiries were destined to receive a satisfactory answer. Alphonse de Candolle was not, however, the first to show that the geographical distribution of organisms was the most important key towards this end. Another great naturalist, A. von Humboldt, in the Addenda to the 3rd Edition of his valuable treatise, 'Ideen zu einer Physiognomik der Gewächse,' makes an observation which, with reference to the question so originally agitated by means of Darwin's work, is of peculiar retrospective interest.

"It is conceivable," says Humboldt, "that on a given area the number of individuals of a class of animals or plants might be numerically limited, and that after many struggles and fluctuations a state of equilibrium would be attained, by reason of the requirements of food and mode of life; but the causes which have geographically limited, not the number of individuals of a form, but the form itself, and have fixed its typical characteristics, lie under the impenetrable veil which still conceals from our eyes all that pertains to the beginning of matter, and the first appearance of organic life."

Unfortunately the great naturalist did not live to see

Darwin's work, which throws such an astonishingly new light on the subject. In the beginning of 1859, whilst working at his 'Cosmos,' in the full enjoyment of his mental powers, he had not the least presentiment that a manuscript was even then ready for the press, which only a few months after his death was destined materially to raise the "impenetrable veil" concealing the most wonderful secrets of nature.

The theory of transmutation, or the doctrine of the gradual development and transformation of all organic forms by means of the very simple law of natural selection, advanced by Charles Darwin in his 'Origin of Species,' has met with since its appearance much approbation, but also much opposition. Nevertheless, the work has had singular success; the important facts contained in it, and the fund of shrewd observation with which the able author supports his views, having excited the general interest in an almost unheard-of degree. It has had further the peculiar merit of bringing forward, in defence of his doctrine, many fresh investigations in the different branches of natural science which had not been previously published. In the present work I will confine myself exclusively to a discussion of the most important facts regarding the geographical distribution of animals and plants, communicated in Chapters XI. and XII. of the above-mentioned work.

Occupied during many years in studying the natural laws of the distribution of organisms, I was struck long ago by certain enigmatical phenomena, on which I often reflected without being able to account for them satisfactorily.

On reading 'The Origin,' I recognized a certain connection between many previously unexplained facts in animal and vegetable geography, and the theory of natural selection. Nevertheless, after careful perusal of the above-mentioned chapters, I was unable to recognize the full signification of natural selection in explaining most of the remarkable phenomena, which meet the eye during an investigation of the Flora and Fauna of the botanical and zoological provinces of all quarters of the globe.

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Darwin's law of natural selection is based, as we all know, on the inherent individual variability of organisms. The slightest variation of an organ in animal or plant may become permanent and hereditary, if it affords an advantage, however small, to the individual in the struggle for existence with other beings, but more especially in competition with others of the same species.

Individual variability, inheritance of new characteristics by the descendants, preservation and enhancement of these characteristics in a certain direction for a series of generations, and all subject to the

struggle for existence, are the three fundamental ideas of the Darwinian theory. Do they suffice to explain the continual and necessary formation of new species? I believe there is a considerable defect in Darwin's theory, and that for its satisfactory explanation, we must call to our aid yet another important law, which I will call the law of the migration of organisms.

Darwin's work neither satisfactorily explains the external cause which gives the first impulse to increased individual variability, and consequently to natural selection; nor that condition which, in connection with a certain advantage in the struggle for life, renders the new characteristics indispensable. The latter is according to my conviction solely fulfilled by the voluntary or passive migration of organisms and colonization, which depends in a great measure upon the configuration of the country; so that only under favourable conditions the home of a new species would be founded.

What to me seems most wanting in the work is a demonstration of the law by which nature, through selection, effects the present wonderful distribution of species in the animal and vegetable kingdoms. The learned author does not appear to have recognized or appreciated the full signification of natural selection in explanation of so many, formerly highly

enigmatical, phenomena in the geographical distribution of organisms, nor the weight of certain facts relative to the migration of animals and plants, in confirming his own theory, and refuting the chief objections to it.

I will now carefully discuss a few facts in animal and vegetable geography, which have an important bearing on this question.

Whilst collecting the material for my 'Fragmenten einer Fauna der Berberei,' in the North of Africa, between the years 1836-1838, I was struck, in investigating the distribution of species of animals peculiar to the country, by the circumstance, that the larger rivers, which flow principally in a northerly direction from the watershed of the Atlas range to the Mediterranean, *formed an effectual barrier to the progress of a considerable number of species.*

Limitation in the distribution of animal species of different classes by watercourses was then almost unknown, certainly unheeded, in zoogeography. Remarkable proofs of the above fact are afforded by the small, peculiarly formed, *Macroscelides Rozeti*, belonging to the class Mammalia, which, confined to the province Oran, has never been found to the East of the river Shelif, whilst the beautifully-striped mouse of Barbary (*Mus Barbarus*) does not occur farther west than the valley of the Shelif. Still more remarkable

is the sharply-defined haunt of *Amphisbaena Wiegmanni*, of the class Reptilia.*

This rare reptile has its eastern limit in the province of Oran on the Shelif, its western on the river Sig, and appears never to have been found in Oran beyond this confined area.

That rivers serve as boundaries is most strikingly illustrated in North Africa by certain families and genera of insects, which, on account of their enormous numerical superiority, variety of form, and mode of life, are better adapted to prove the Darwinian theory than any other class of animals or even plants, the total number of species of which only equals about one-fourth those of insects. In the case of insects, voluntary, as well as passive (by wind and water, &c.) migration has always been in operation, whilst the latter alone affects the distribution of plants. Compared with higher classes of animals, insects are infinitely more important in the investigation of this question, because much less affected by civilization, their distribution not being confined or checked in the same degree by increased human colonization as in the case of mammals, birds, and reptiles. The wonderful metamorphoses of insects, their manifold modes

* These, and all other animal species of Northern Africa here mentioned, are described in the 3rd vol. of my 'Reisen in der Regentschaft Algier,' published at Leipzig in 1841, and are illustrated by coloured plates in the Atlas of the same work.

of existence even in the larval state, but more especially their varied powers of locomotion, render their geographical distribution one of the most important means of proving the truth of natural selection, and of arriving at the knowledge of the law through which it influenced the distribution of forms.

In North Africa very important data are furnished by certain varieties of beetles, especially by the section Heteromera, many species of which live almost exclusively on the saliferous sands of the sea coast. The majority of these Heteromera, abruptly separated by river beds, belong to the *Melasomæ* chiefly to the genera *Pimelia*, *Blaps*, *Adesmia*, *Erodius*, *Asida*, *Tentyria*. Species of the genera *Graphypterus* and *Sepidium*, so characteristic of North Africa, occur on a limited area determined by rivers.

I observed the same to be the case with the numerous specimens I collected, mostly endemical snails. As for example *Helix hieroglyphicula*, which is not found farther east than the Shelif, whilst the western boundary of *H. vermiculata* is equally sharply defined by the same rapid river.

This remarkable fact in the limitation of species by so small a natural barrier as a river of moderate breadth was, after its publication in 1841, curiously interpreted by a late naturalist, a rigid adherent to the letter of the Mosaic record. "Geographical distribu-

tion of species," he says, "was determined by the fiat of the Almighty from the beginning." For this reason the swallows never swerve in their migrations towards the south, although with their powers of rapid flight, they could in a few hours just as easily traverse the Atlantic.

I objected that the migratory rat of Asia, *Mus decumanus*, confines its wanderings to a particular direction just as little as the migratory locust, which sometimes infests tracts where it had never been before; but this, together with many other similar examples in opposition to the dogma of the primordial demarcation of animal distribution, remained unanswered. An arbitrary determination of the area occupied by each species must certainly have implied some particular aim of the Creator which we are unable to discover. But is it possible to go so far as to believe that there was a special act of creation for a species of *Scarabæus* with punctured elytra, geographically limited to one bank of a river, whilst on the opposite shore a second act was necessary to produce a beetle of the same genus with smooth elytra? Such an interpretation of the works of the Creator must appear somewhat trifling to us all.

It is to be observed that only animals of limited mobility are confined by such narrow barriers; amongst the Coleoptera almost exclusively those of genera, the

elytra of which having grown together, form a horny covering rendering the beetle incapable of flight. Similar instances occur in certain cases of Hymenoptera, Lepidoptera, and Diptera, but then the barrier is formed by a volume of water over five miles in breadth, such as the Straits of Gibraltar, not by streams of moderate breadth like the rivers of Algeria. Of indigenous insects of different orders, dispersed through the length and breadth of Algeria and probably over the whole of Barbary, but which appear to be entirely wanting in the south of Spain, I will mention *Pontia Dorei* and *Hipparchia Meone* belonging to the Lepidoptera, *Eucera pyrrhula* and *Megilla quadricolor* to the Hymenoptera, *Stratiomys auriflua* and *Volucella liquida* to the Diptera, all possessing considerable powers of locomotion, and to the onward progress of which even a rather broad river presents no obstacle. These species were no less incapable of crossing the Straits of Gibraltar than the above-mentioned small mammals and Coleoptera. Beetles which fly easily have never been known to be arrested by rivers. *Saperda glauca*, *Hamaticherus Nerii*, and almost every kind of Buprestidæ occur both east and west of the Shelif.

✓ A still more striking fact is, that species of the same genus when separated by river valleys are, as a general rule, remarkably alike. Under these conditions Mela-

somæ generally show a much nearer relationship of form with each other than with others which occur at greater distances. We seldom meet with two very similar species in great numbers inhabitants of the same station; but when this is the case, the furthest limits of their occurrence are always considerably divergent, and the number of individuals of the two species is generally very unequal. The frequency of a species seems to have a modifying influence upon the increase of the species most nearly related to it.

The separation of species, especially those of clumsy build, by broad rivers, I have often more recently observed in other countries, particularly in the case of insects which cannot fly. The lower Danube separates a number of Coleoptera, principally Carabidæ, some of which only occur in Wallachia or Bulgaria. The Kur, Araxes, and Euphrates form barriers separating a great number of animal, as well as vegetable species.

This fact may be strikingly illustrated by the deep and rushing Kisil-Irmak in Asia Minor, which empties itself between Sinope and Samsun into the Black Sea. The Kisil-Irmak distinctly marks the boundary line of a number of lower animal species, *e. g.* the magnificent *Carabus Bonplandi*, occurring from Samsun to Trapezunt and even as far as Tokat, but suddenly disappearing to the west of the Kisil-Irmak. The

same river separates other very characteristic species ; for instance, of Carabidæ a spotted kind of the genus *Procrustes*, which is limited to its western bank, whilst an unspotted species (*P. græcus*) is confined to the eastern side. Separation by watercourses, I further most decidedly observed in the case of most of the species belonging to the genus *Dorcadion* of the family *Cerambycidaæ*, which do not live upon trees and bushes like other genera of this family, but creep awkwardly along the ground, incapable of flight, their wings—probably through disuse—having grown together.

✓ The broader and more rapid the stream the more frequent is this phenomenon ; the direction of the stream has not the slightest influence. The Missouri and the Mississippi, but above all the St. Lawrence, ✓ one of the broadest and largest rivers in the world, have on both banks a somewhat dissimilar Fauna ; this difference, however, exists only in the species, not in the genera, and is only to be met with in the case of species with inferior powers of locomotion, which would only be able to cross such watery barriers by the greatest chance. Whilst on the one hand I was unable to discover the slightest difference in the birds, butterflies, Hymenoptera, or Neuroptera on either bank of the St. Lawrence ; on the other hand not a few reptiles, Arachnida, Coleoptera, and land

snails, were very decidedly arrested by this the largest of North American streams.

The same has been found in Germany to be the case with plants. Otto Sandtner cites forty different species in Bavaria which are arrested by rivers. The Danube, for instance, is the northern limit of *fifteen*, the Lech the eastern limit of *seven*, and the western of seven other species. The Isar was the eastern limit of *Avena versicolor*, the western of *Dianthus Seguerii*, *Alsine austriaca*, *Astrantia carniolica*, *Verbascum phœniceum*, *Pedicularis incarnata*. The Traun forms an eastern limit only of *five* species, the Saalach the western boundary of *fifteen*.

More decided and more frequent is the separation of species, animal as well as vegetable, by mountain chains. Even in the Alps, the northern and southern flanks separate many species. The barrier is more distinct in the Pyrenees, which are more closed, and form, on account of the scarcity of passes, a wall difficult to surmount. The Caucasus, being a higher range with only two depressions, divides—still more strikingly than the Pyrenees—the Fauna and Flora of the plains of the Terek and Kuban from the organic forms of Trans-Caucasia.

At the foot of the opposite declivities of a mountain range the above phenomenon is repeated much more frequently than on opposite river banks, with the

specific difference, that in this first case many species present yet more striking vicarious appearances. Nearly every *Carabus* which I collected in the forests of Grusia at the southern foot of the Caucasus, reminded me of a similar one on its northern side, which was more nearly related to it than other species of the same genus from more distant tracts. The same law applies to plants.

Climatic causes are insufficient to explain these facts; for we observe the same unaltered in mountain chains, which, like the Ural and the South American Andes, run in the direction of the meridian, and consequently do not divide very different climates; and again in others, which, like the Caucasus and the Pyrenees, lie more east and west. The Flora and Fauna of the primeval forests in the Eastern and Western Andes of Ecuador show still greater specific varieties than the northern and southern sides of the Caucasus, which separate two very different climates; whereas there is no important difference in the climatic conditions between the opposite slopes of the equatorial Andes.

In the province of Darien, in the state of Panama, on the other hand, the above-mentioned phenomena in the geographical distribution of organisms suddenly change; here the characteristic topography of the South American Andes abruptly terminates: a high

mountain range, running in a meridional direction, changes to a low secondary range, with deep depressions, the Cordillera of the Isthmus of Darien, running in a contrary direction (east and west). The great majority of plants and animals collected by myself on the Rio Chagres, which empties itself into the Carribean Sea, were specifically identical with those I afterwards found at the mouths of the rivers which flow into the Pacific Ocean, notwithstanding that the climates of the two coasts of Panama differ greatly. The lower mountain range of Panama does not, however, by any means form so impassable a barrier as the Andes of South America. The deep depression of the isthmus proper, where the Cordillera entirely disappear, promote, under these more favourable conditions, a mutual exchange of forms.

Very remarkable facts are brought to light in regard to this by comparing island Fauna with that of the nearest continent. Not only does the relative difference of animal species increase almost everywhere in a ratio proportional to the greater or less extent of the intercepting water, but also that of the genera. Thus the islands of Coiba, which are only separated by a narrow channel from the Central American isthmus, have the same species as the latter, but present some remarkable varieties. The Galapagos, distant 160 geographical miles from the American

continent, have, on the other hand, with the exception of a few birds, only peculiar animal species; but these all most decidedly betray the American type, and approach nearest to the Fauna of Chili. Each of the islands, separated by tolerably broad and deep arms of the sea, has the same genera of birds, insects, and land shells, but different species; the latter are, however, more nearly related to each other than to species of the same genera inhabiting Chili.

Thus, for instance, there are upon these islands thirteen kinds of finches, constituting a perfect gradation, not only in regard to the plumage, but also in regard to size and shape of the bill. Whilst some kinds have a very thick, and others a moderately thick bill, we find some the bill of which is as thin as that of the *Sylvidæ*; we can thus trace in this genus all transitions and gradations of the species. Each of the three principal islands has its peculiar species of indigenous mocking birds. *Orpheus trifasciatus* inhabits Charles Island, *O. parvulus*, Albemarle Island, and *O. melanotus*, Chatham Island.

In the colour of the plumage, the structure of the several organs, in fact in general appearance as well as in mode of life, these different species exhibit a most extraordinary resemblance; but each island possesses one species only. They must, therefore, represent each other in the economy of the different islands.

The vegetation, to judge from the herbarium collected by the expedition of the 'Beagle,' and classified by Henslow, presents the same peculiarity. The berry-producing Quayavito tree of James Island is not found upon Charles Island, and the plants of the different islands, although exceedingly similar, are either specifically different or distinct varieties.

All islands which are equally distant from the nearest continent present very similar phenomena. The zoology and botany of New Zealand, in spite of their respective peculiarities, have a decidedly typical relationship to those of South Australia, those of the Falkland Islands to Patagonia, and of the Cape de Verde Islands to Western Africa. Even the Fauna and Flora of Madagascar, which Dr. Schmarder, referring to its organic riches, called the sixth quarter of the globe, have more typical resemblance to those of South-Eastern Africa than to any other more distant land.

This remarkable dependence of the character of insular organic life on the nearest continent, even when separated from it by over 100 geographical miles, is an important fact which repeats itself everywhere, and points to a common cause.

It was not till some time after his return, that the contemplation of the Flora and Fauna of the Galapagos led Darwin, as he says in his latest work, to the idea

of natural selection. When, in October, 1835, he was reluctantly compelled to leave this Archipelago after a comparatively short sojourn, he was still very far from the idea of attempting to solve the great enigma of the origin of species. In his work of 1845 he still spoke somewhat vaguely of these phenomena. "This typical similarity between organisms of distant islands and the nearest continents has scarcely been sufficiently investigated. According to the views of some authors, it might be accounted for by assuming that the creative force had acted over a great area according to the same laws." This proves how far was the view of the celebrated author then from his subsequent theory, published only twelve years later.

Without entering into an enumeration of a long series of similar facts in the animal and vegetable geography of Europe and other quarters of the world, which would furnish further data in support of my views on the course of these remarkable phenomena in the distribution of organisms, I will confine myself to a *résumé* of the most important points above cited.

Rivers, mountain chains, and seas form distinct lines of demarcation in the distribution of many varieties, species and genera. High mountain ranges separate organic forms more decidedly than rivers, and seas, especially when of considerable extent or devoid of islands, in yet higher degree.

The broader and more rapid the river, the higher and more regular the mountain chain, the calmer (*i. e.* the less disturbed by strong currents and violent storms) and more extensive the sea, the more decided is, almost invariably, the barrier between different organisms, and the greater will be the number of varieties, species, and even genera separated by it; further, the distribution of organisms in a certain direction will have more the appearance of abrupt termination, and the peculiarity of the Flora and Fauna will be the more striking.

On both sides of the boundaries endemic species will appear as so-called vicarious forms (or forms similar to neighbouring ones) separated from each other by these barriers. Such species show, as a general rule, a yet nearer typical relationship to each other than to species of the same genus formed at greater distances. On oceanic islands the number of species very nearly related to distant continental ones is small; the prevailing types of families and genera, nevertheless, recall those of the nearest continent. In a group of islands, species peculiar to each particular island generally betray a very near relationship to other species on the next.

Those classes, orders, and genera which comprise animals of inferior powers of locomotion, generally have the greatest number of species peculiar to a country.

Two zoological provinces, on the other hand, possessing a great number of birds, or animals which are good swimmers, will have a relatively large number of identical species and genera, even though they are separated by mountains or seas. Cheiroptera are more widely distributed than species of any other family of mammals; and birds, on the whole, incomparably more so than reptiles or fresh-water fish. Lepidoptera, Hymenoptera and Neuroptera have generally fewer endemic species than Coleoptera, which, in consequence of a heavier covering to their bodies, are much less mobile. Crustacea and marine Conchilia are always more extensively dispersed than snails.

All the examples here given would be incomprehensible without the assumption of a voluntary or passive migration and natural selection so closely connected with it. These two factors conjointly easily explain them.

Every species, animal or plant, as is well known, has its particular station, generally endemic but sometimes sporadic, which, in the case of many, covers more than an eighth of the globe, and in the case of some plants, mammals, birds and insects, extends over several continents. We see that every kind of plant or animal, by reason of its morphological or physiological organization, extends its haunts as far as physical conditions,

external and internal, will admit. These external conditions are by no means solely geographical or climatic, as certain geographers have assumed before the publication of Darwin's work; they depend far more on the competition, or struggle for existence, of all organisms. In the plains of the northern hemisphere the station of a species when of small extent, is in the form of an ellipse, the major axis of which lies as a rule east and west, if not modified by mountains or broad rivers.

In the continual struggle between individuals of the same species for food and reproduction, some must always be endeavouring to cross the limits of their respective stations. The extreme boundaries must therefore be continually changing, according as some individuals find means, either by voluntary or passive migration, to pass the station of their species.

This tendency to emigration is, in the struggle of all organisms for preservation and increase, a deeply-rooted necessity in the law of nature. The proof of this we observe on a truly grand scale at the extreme limits of the two great opponents, the primeval forest and the savannah or treeless grassy expanse of tropical America, where an unceasing struggle and change is going on. There, such trees as the very remarkable Chumico (*Curatella americana*, L.), the Espino de

paloma (*Duranta plumieri*, Jacq.), and the so-called Chumico bejuco (*Davilla lucida*, Presl.) originated; * these act as pioneers to the emigrants of the forest, and having adapted themselves to new conditions, especially to the dryness and glare of the savannah, only thrive at the extreme edge of the forest; they must consequently invade the savannah when the area of forests is extended. Doubtless similar cases existed in Europe at a time when that quarter of the globe was for the greater part covered with virgin forests.

In the animal kingdom this struggle is far greater, because motion is there added to passive or chance migration. The stronger individuals were, in all probability, impelled by the want of better food, the weaker by the desire to withdraw themselves from competition with the more powerful of their species, or from persecution by birds and beasts of prey, to abandon the station by crossing such barriers as rivers or mountain ranges.

* Side by side with these we find other species, especially of the families *Dilleniaceæ*, *Verbenaceæ*, *Malpighiaceæ*, *Bythneriaceæ*, *Leguminosæ*; all equally important as pioneers in preparing the way for the remaining forest trees, which require more shade and moisture. This continual struggle of the forest with the savannah in tropical America is a highly remarkable phenomenon. In all probability it would result in the complete victory of the forests, if the Indians and colonists did not by means of fire protect these all-important grazing grounds against their encroachments. In the still drier steppes of Tartary, the peculiar leafless Sapaul (*Haloxylon ammოდendron*, Bun.) appears to act a very similar part. It provides the steppes bordering the Aral Lake, which would otherwise be bare, with a little wood.

Should the new colony, founded by such wanderers, lie very close to the old station, and be inadequately protected by mountain or river barriers from frequent communication with the parent stock, then both limits will soon be effaced, and the new colony become one with the old station. In this case a constant variety or new species cannot be produced, because the free crossing of a new variety with the old unaltered stock will always cause it to revert to the original type; in other words, will destroy the new form.*

The formation of a real variety, which Darwin, as we know, regards as the commencement of a new species, will only succeed when a few individuals, having crossed the barriers of their station, are able to separate themselves for a long time from the old stock.

The migration to a new district where the species appears for the first time, must always involve a certain amount of change in the condition of life, especially in the quantity and quality of the food. Darwin, in his latest work on the variation of animals

* This tendency of all animals and plants to migrate, arising out of the two most powerful natural impulses self-preservation and reproduction, is a deeply-seated necessity, which may be placed side by side with the emigration fever in the overpopulated countries of Europe. The hundreds of thousands of emigrants who yearly leave Europe are impelled by the same causes, *viz.* the increasing difficulty of supporting themselves and their families.

and plants in a state of domestication, rightly attaches the greatest importance to the influence of food. More abundant food, which must always give impetus to many internal physiological changes of the organism, hinders animals from exerting themselves so much. Disuse of one organ will reduce it and correlation of growth connects the organization in such a manner, that the variation of one part of the body causes a change in others.

Under these altered conditions of life—on which the climate has but slight direct influence—the quality of individual variability inherent in every organism, and without which natural selection is not conceivable, must be greatly enhanced. Should this increased plasticity of the organization be promoted in one direction by local circumstances during a series of generations of isolation, the result will be, natural selection continuing, the so-called constant variety, or more correctly, the commencement of a new species. The first altered descendants of such colonists thus become the parent stock, and their home the centre of the station of a new species.

The formation and continuance of a race will always be endangered where numerous individuals of the original stock become mixed up with, and by frequent crossings disturb, or entirely suppress it. Unless the separation of the colonists from the kindred species

continue for a long time, the formation of a new race cannot according to my conviction succeed, nor natural selection become active. Free crossing, as the artificial selection of animals and plants incontestably teaches, not only renders the formation of new races impossible, but invariably destroys newly-formed individual varieties; it is, moreover, the principal cause that individual variability does not, after several generations, effect a lasting change. The unlimited sexual intercourse of all individuals of a species must always result in uniformity, and varieties, the characteristics of which have not become permanent through a series of generations, must again revert to the old form.

This fact is placed beyond doubt by experience, and numerous investigations published by Darwin himself. In his book on 'Animals and Plants under Domestication,' page 85 of 2nd volume, we find:—
 "It is free intercrossing which chiefly gives uniformity, both under nature and under domestication; to the individuals of the same species or variety, when they live mingled together, and are not exposed to any cause inducing excessive variability. The prevention of free crossing and the intentional matching of individual animals are the corner stones of the breeder's art. No man in his senses would expect to improve or modify a breed in any particular

✓ manner, or keep an old breed true and distinct, unless he separated his animals."

In the same work Darwin remarks, certainly very correctly, that though it was easy for man to obtain an extraordinary multiplicity of forms in dogs, because their selection is in his power, he was unsuccessful in obtaining many different races of cats by selection, because crosses of the latter were not easily to be avoided on account of their nocturnal wanderings.

I would here remind the reader of the well-known fact, that throughout Turkey in Asia there is but one single race of dogs. A religious custom forbids the admittance of the dog into the house as an unclean animal; the consequence is that the unhindered pairing of the half-wild dogs renders equally impossible the formation of new breeds, and the preservation of imported types. Such is also the case in tropical America, where it is not religious custom, but the climate which obliges man to let the dog go free, so that there also we find only one breed.

As with the selection of domesticated animals, so it is in nature in the case of each individual emigrant which has crossed the boundary of its former station, and become permanently separated from its species. Altered conditions enhance individual variability, and isolation favours the beginning of a new race. From the numerous facts brought forward by Darwin it is

conclusively proved that the individuals of every new race or sub-race are more variable under domestication than in a state of nature, and the change is, from physiological causes as yet unexplained, sudden and very sharply defined. Such variations are, as a general rule, inherited by descendants, but of course only when unimpeded by frequent crosses with the original stock. The astonishing results obtained by the most experienced pigeon fanciers, are only arrived at by keeping a single breed, by careful selection, and by isolation. no

It is certainly favourable for the formation of new species, but by no means always necessary, that, effectually to separate emigrants from their former station, the barrier to be surmounted should be as difficult as a broad river, a high mountain range, or a sea. Any considerable intervening area between the old and new station is sufficient. Every chance removal of the species to a considerable distance from the extreme limits of a former station, or any sudden transportation to a country where orographical conditions favour an independent and separate existence of the emigrants, may have a like effect. no

Every prolonged isolation of colonists admits of their descendants developing in a higher degree any modifications of particular organs, acquired through altered conditions, always provided that they are not disturbed by intermixture with the old stock. no

I need scarcely say that nature has at its disposal numerous, and in many cases highly remarkable, means of transport. Chance often brings about the passive migration of plants, tadpoles, the spawn of fish, small molluscs, insect eggs, and so forth. Darwin's work contains on this subject many interesting observations, and to these I will only add one instance.

When in October, 1836, the obelisk of Luxor was taken out of its wooden case, after lying two years in Paris, and was set up in the Place de la Concorde, a small colony of live Egyptian scorpions, belonging to the twelve-eyed genus *Androctonus*, was found in the wooden case. They were made over to Professor Andouin, then Conservator of the entomological department of the Jardin des Plantes. These splendid Arachnidæ, thus involuntarily transported from the ruins of Thebes to the north of France, had not only withstood the inclemency of two winters, but also found means of supporting themselves, and probably of increasing their number. Now, if chance had so willed it that these Arachnidæ, instead of being set down in a populous centre of civilization, should have been deposited on the voyage—which lasted many months—anywhere else (for instance, on the sea-shore of Toulon), they would probably have multiplied, and enriched the Fauna of southern France with a species

of scorpion which it does not now possess. But had such been the case, the different conditions to which they must have been subjected would in all probability have produced a variety, and ultimately resulted in the formation of a new species.

A kind of beetle of the genus *Tetracha*, inhabiting tropical America, presents a most remarkable example of how individuals of a species, having accidentally strayed or been transported to a neighbouring territory, may, in a comparatively short space of time, through complete isolation and very altered conditions, be changed in form, colour, and mode of life, and thus become an entirely new species. The mode of life of this genus is identical with that of the genus *Megacephala* of the Old World, so well known to all entomologists, of which the American genus *Tetracha*, properly speaking, forms a sub-genus. *Tetracha carolina*, L., and *T. geniculata*, Chev., pursue the same gregarious mode of life as the Asiatic *Megacephala euphratica*; both are very numerous in the dampest parts of sandy river banks, and both require a damp climate. Even in the night, when they conceal themselves under stones or fallen trunks, they confine themselves to places saturated with water, and are but rarely to be met with inland.

The rivers of Venezuela and of the western part of Central America, where the last-mentioned species

abounds, flow partly through savannahs, where they have undermined the loose tufaceous soil, forming deep beds with high precipitous banks. Individuals of this species from the highlands, through which the river passes, have arrived, by accident or otherwise, at the level unwatered soil of the savannah, and cannot return without precipitating themselves down the perpendicular bank ; the consequence has been that an entirely new species, longer and slighter, and with the elytra of a peculiar black, has been formed from the brilliant green stock by these stray individuals, and this probably in a very short space of time. *Tetracha Lacordairei*, Gory, and the variety *T. elongata*, in direct contrast to the usual habits of the rest of the species of this genus, have adapted themselves to completely different conditions of life in the dry steppe. They do not live gregariously, but singly, under stones, and only sally forth during the morning hours of sunshine in chase of small Diptera. The metallic lustre of their elytra appears to have disappeared from the effects of dryness. The formation of this dark species, of which there are many varieties, cannot possibly be older than the time required by the rivers to undermine the loose soil of the savannah.

We may be certain that, from similar causes, many kinds of beetles distributed over the Cordillera at different elevations, have arisen during a long separa-

tion from their earlier comrades. Such transformation is well exemplified by certain species of the remarkable genus *Zopherus*, which, on account of their curious form, are often kept alive by Indians in their wigwams, and which may by this means have been transported to the highlands, where a small stunted species has arisen.

Amongst the higher classes of animals the rattlesnake affords another example. *Crotalus horridus* abounds in the dry savannahs of the lowlands of Nicaragua and Guanacaste. On the plateau of Costa Rica, 4000 feet above the level of the sea, there occurs, though rarely, a small similar but yet distinct kind, which Dr. Fitzinger, on examination of the specimen I had brought with me, described as a most decided species. This venomous snake is an emigrant from the plains, but has adapted itself to the different mode of life of the highlands; in consequence, however, of scantier nourishment, it is smaller and stunted.

These instances, particularly those of the above-mentioned genera of beetles, are very important, for they prove, what is under any circumstances very probable, that a change of species, in consequence of changed conditions of life, is not necessarily a perfecting of the form, but often, if the food has been bad, a retrogression, which will be maintained and even inherited, if by adaptability to circumstances it affords the new species a local advantage. The slender

build and dark colouring of *Tetracha elongata* of the steppe, compared with the well-fed and brilliant *T. geniculata* of the river bank, certainly show no progress of organization, but as certainly stand the carnivorous beetle in good stead, when his food is difficult to procure.*

The majority of our alpine plants and insects resemble nearly related species, which are to be found in the plains at the foot of the Alps, or at different elevations on the slopes. Their origin is also easily explained by the law of migration. Migration from the plains upwards, added to sufficiently long and distant separation from the station of the lower region, was the more favourable to the formation of varieties, inasmuch as the different climates of the heights must have caused a still greater change in the conditions of life, and have exercised thereby a stronger influence on the individual variability of the organism.

Like islands these different elevations were (and are even yet, though in a much more limited degree than formerly) so many natural stations for experi-

* The brown bear, compared with the larger and more powerful diluvial cave-bear, from which it probably descended, is equally a case of organic retrogression, but its stunted form was better adapted to the altered circumstances of the glacial period, when food was difficult to procure, than that of the cave-bear. The latter, the largest beast of prey of the post-tertiary era, was gradually driven from its dwelling, by its contemporary human inhabitant, who with his artificial weapons of stone and bone became a formidable rival in the struggle for existence.

ments in the formation of new races, always provided that the species in the plains were successful in settling and subsisting far from their former station.

It is obvious that the difficulty of settling would be considerably increased anywhere where the heights were already thickly populated by nearly related species, and that only under the most favourable circumstances the immigration of a few individuals would result in a permanent colony, and with it in the commencement of a new species. Great climatic changes, such as occurred before and after the last great glacial period, had probably only a very slight direct influence on the formation of new species; but their indirect influence must have been immeasurably great; for the majority, compelled to emigrate from north to south, would afterwards, through a partial reaction, be forced back. These frequent colossal migrations before and after the glacial period were undoubtedly favourable to the formation of many new species by means of selection, which would not without those migrations have been called into action. The unusually numerous vicarious forms of the vegetable and animal kingdoms of North America, which resemble so strikingly related species in the north of Asia and Europe, have, it is highly probable, proceeded from the migrations of that period.

cf.
Agas

Very important proofs of the tendency of organisms

to increased variability by the separation of single individuals from the former station of the species, are afforded by the Andes of the equatorial zone of South America. Nowhere does nature appear to have in a higher degree favoured the isolation, and consequently the formation, of varieties and species of the animals and plants occupying the intermediate and higher regions, than on the double row of mountain cones and volcanoes of Quito. Almost every one of these gigantic isolated mountains possesses, so to say, its peculiar Flora and Fauna, or in other words, a number of varieties and species which are wanting on the neighbouring mountains, but are nevertheless nearly related to those of the nearest. The same phenomenon may surely be observed on every high mountain range of like topography.

Humboldt and Bonpland's fine collection of plants, examined and described by Kunth, was the first confirmation of the separate local occurrence of any species of alpine plants on the volcanoes of Quito, the places in which they were found being accurately given. Each of these colossal mountains overtops the line of perpetual snow, bearing a mighty snow-cap (nevado) of imperishable splendour, which, by condensing the surrounding vapour and cooling the atmosphere, exercises a peculiar influence on the character of the vegetation of the higher regions.

Nearly all the volcanic cones of these highlands stand isolated at intervals of two to four geographical miles. On the summit of the chain (Cordillera), on the border of which the volcanoes, for the most part now extinct, arose much later, and from less extensive upheavals than the chain itself, the snowy range, which begins at an elevation of 14,200 Paris feet, is not reached.

It is easily conceivable how these huge isolated mountains of the plateau, which exceed the height of the Cordillera by 4000 to 5000 feet, must have promoted the formation of new varieties and species by the separation of immigrant organisms. From this we may deduce the important fact, that the more isolated each cone of this highland, the richer must be its Flora and Fauna in peculiar species.

In the vegetable kingdom undoubtable proofs of this are furnished, by the alpine genera *Culcitium*, *Weinmannia*, *Salvia*, *Eupatorium*, *Gentiana*. Of the last-named genus we found, for example, *Gentiana rupicola* and *G. caespitosa* on the Antisani and Cotopaxi, but neither on the Chimborazo, which in their stead possesses a purple red species, *G. cernua*. The latter, again, is not to be found on the neighbouring volcano Tunguragua, but is there represented at the same elevation by a pale rose-coloured species *G. gracilis*, while the Ilinissa produces almost at the same height a

white kind, *G. limoselloides*, and the Pichincha a blue one, *G. diffusa*.

The *Saxifraga* discovered by Boussingault, which bears his name, was found above the snow line of the Chimborazo, the highest station reached by any vascular plant in the world; it is, moreover, peculiar to the mountain, and quite different to the *Saxifraga andicola* of the Pichincha. Again, the *Sida pichinensis* is peculiar to the alpine regions of the Pichincha, and is not to be found on the Chimborazo or Ilinissa.

In like manner the blue *Salvia macrostachya* of the large genus *Salvia*, is replaced on the Ilinissa by the blood-red *S. phoenicea*.

The rich collection of plants which my friend Dr. Jameson made in Quito during a sojourn of many years, and the herbarium which I myself brought from this wonderful highland, confirm the important fact—first proved by Humboldt and Bonpland, though without knowledge of the cause—of the isolated occurrences of many plant species on the several volcanoes of Quito.

This appears particularly to be the case with the Flora in craters of extinct, or feebly active, volcanoes.

The Fauna of the higher regions of these colossal isolated mountains, displays quite analogous phenomena. Each mountain possesses certain peculiar animal species, which occasionally appear on the nearest

volcano, but are often wanting on more distant cones. The Pichincha, for example, produces on its snow border a species of the beetle genus *Colpodes* smaller than that of the Chimborazo and Conderasto. Species of Lepidoptera also—of the genera *Colias*, *Pontia*, and *Hipparchia*—differ on different mountains. Even the two strangely formed *Prenadilla* species, fresh-water fish of the shad family, which belong to the highest region, and which Valenciennes described as generically distinct, never occur there together, but always in separate waters.

Still more noticeable is the occurrence on almost every one of these different cones of peculiar alpine species of Colibri. Gould, in his voluminous monograph on the trochilites, has already pointed out that this truly American family of birds is represented in each region of the Andes by genera and species peculiar to certain altitudes. As examples, I may mention the splendidly coloured species *Eugenia imperatrix*, discovered by Dr. Jameson, and named by Mr. Gould after the Empress of the French, which is confined on the west side of the Pichincha to the forest region at an elevation of 6000 to 8000 Paris feet. *Lesbia amaryllis*, *Eriocnemis Luciani*, and the wonderfully shaped *Docimastes ensiferus*, which possesses of all birds in the world the relatively largest bill, inhabit the same mountain at an elevation of 9000 to

11,000 feet. Higher up, at about 11,500 feet, appears the beautiful species *Petasophora arrais*, which disappears at 13,000 feet, and gives place to *Oreotrochilus Pichincha*, Gould, which inhabits exclusively the highest region bordering on the line of perpetual snow, at a height of 14,200 feet, and appears seldom or never to leave it.

In exactly the same region there occurs on the Chimborazo a peculiar local variety of the same species of Colibri, which is distinguished from it by a green stripe under the throat, in consequence of which it has been described by Gould as a distinct species (*Oreotrochilus Chimborazo*).

The extraordinary phenomenon of so many species of plants and animals on the volcanoes and isolated mountains of Quito is very significant. Without the distribution of organisms by migration in connection with local selection it would be inexplicable. The gigantic isolated mountains of this highland act a similar part in the formation of varieties and species as the insects of the Archipelagos, for instance, of the Galapagos. When we consider the facility with which stray wanderers, separated from their stations, must become naturalized and be able to continue in long isolation, they appear as if created for natural selection.

The peculiar form of the equatorial Andes, with

bell-shaped, isolated mountains, for the most part extinct volcanoes—all of them, however, more recent and considerably higher than the ridge of the two principal chains—was incomparably more favourable to the isolated colonization of organisms than the high mountains of the Old World. The elevation of the highlands of Quito was no less advantageous to the formation of endemic varieties and species than to the development of alpine forms on isolated cones. Besides the ever-changing species of the different regions on the slopes of the range, which present appearances analogous to certain phenomena in the Alps and Pyrenees, we find on single mountains in the highlands of Quito numerous changes of species, a phenomenon which in the mountain ranges of the Old World is rarely met with, and nowhere else so typically or on so grand a scale.

Parrot found on the highest region of the Kasbek, in the Caucasus, a species of plant of the genus *Cerastium*, peculiar to this mountain. M. Ménétriés found on the Elbruz several fine Carabidæ which do not occur on the other mountains of the central Caucasian chain. In our own Alps not a few species of plants and insects occur which are confined to certain parts. For instance, a remarkable plant of the family of Labiatae (*Wulfenia carinthiaca*) occurs exclusively in a confined valley of the Carinthian mountains.

Another decided species of the family of Cruciferæ (*Braya alpina*) is found in a few valleys of the Alps only. *Plusia mya* and *P. deaurata*, two splendid alpine butterflies of the family Noctuidæ, are as yet only known in one spot in a valley of the Valais, and *Bombyx Euprepia flava* is confined to the valley of the Upper Engadine.*

Of all the mountain chains of the Old World the lofty Armenian range bears the greatest topographical resemblance to the Andes of Quito. The Greater and the Lesser Ararat, the Allahgos, and the volcanic group on Lake Goktshai, are in an almost equal degree separated from each other, and overtop at the same time the lower Caucasus and the Armenian Taurus. Here in reality a phenomenon is presented by the Flora and Fauna, similar—although on a far smaller scale—to that of the equatorial highlands of America, which represent five times the number of volcanoes.

Each isolated group has one or more species of plants and animals peculiar to it, which are replaced on the next volcano by closely allied species. Thus, for instance, a black species of a genus of Carabidæ

* In the year 1850 I was so fortunate as to find in the valley of Upper Engadine (Canton Grisons), 5000 feet above the sea, this beautiful species, which Esper had drawn and described fifty years before, without its station, however, having become known. It appears that this fine Bombyx only frequents this one high valley of Europe.

(*Callisthenes*) belongs to Mount Ararat, whilst a large bluish species of the same genus, entirely wanting in the Caucasus, occurs on the Allahgos. In the volcanic basin of Lake Goktshai I discovered two new and locally very common species of the genus *Dorcadion* (*D. nitidum* and *D. dimidiatum*), which as yet have only been found there. On the slopes of the greater Ararat they are represented by another species of the same genus, which is peculiar to this mountain.

If the occurrence of peculiar species in certain limited localities of the Caucasus and Himalaya, of the Alps and the Pyrenees, is rarer than in Armenia, and still rarer than in the volcanic highlands of Quito, it is quite easily explained by the difference in the plastic forms of those ranges. Extended plateaux and isolated volcanoes between the chains, so favourable to the formation of endemic species, are entirely unknown in the Alps and Pyrenees. The emigrants of the vegetable and animal kingdoms wandering upwards from the plains or lower levels, could only by taking a vertical direction separate themselves from the station of their species, and by undisturbed colonization of the higher regions find a favourable field for the formation of races.

For this reason the change of species in the Alps is as a rule in a vertical direction, whilst in the Andes of Quito, where organisms in the act of migrating could isolate themselves for a time on each single

volcano, the succession occurs also in a horizontal direction.

All vegetable and animal species of the upper regions of our highlands appear to have been formed, during longer or shorter periods of isolation from the parent stock, by the undisturbed development of each slight variation in a particular direction; the forms from which they sprang appear to have migrated from the lower regions, partly before and partly after the glacial period, and these latter again from forms inhabiting the plains at the foot of the mountains; to this process every migration involving somewhat altered conditions of life must have given renewed impetus.

All species which our mountains possess in common with the Flora and Fauna of the polar regions, we consider as having arisen before the glacial period, but all peculiar species after that era; further, that their inherited characteristics were enhanced by natural selection, provided that separation from the station of the older stock protected the varieties from frequent crosses with fresh immigrants.

We can thus see in our alpine plants and insects the generic forms of the lower regions represented by other species or varieties of the higher ground, to be followed at still greater elevations by genera with yet more altered species. Their present differences were, as

already observed, the result of the gradual development of individual characteristics, proceeding from altered external conditions of life, and dependent on sufficiently protracted isolation.

All kinds of the well-known genera of plants, *Hieracium*, *Gnaphalium*, *Gentiana*, *Potentilla*, *Ranunculus*, *Polygala*, *Campanula*, *Cerastium*, *Poa*, *Saxifraga*, and others, which in great numbers adorn our alpine regions from 5300 feet up to 7500 feet and over, recal to our mind other species of the same genera occurring at moderate heights of from 1700 feet to 5300 feet, which Otto Sandtner terms "higher and lower mountain region" respectively. Lower down, from 800 feet to 1700 feet, are repeated the genera of both divisions. When by chance there occur strange forms altogether wanting in the nearest lower regions, it is most probable, even though we assume the sometimes doubtful character of a genus to be indisputable, that similar genera existed in a former period (before the glacial epoch), and that they only became extinct in lower stations because there the external conditions of life were changed.

We observe the same with regard to insects. All beetles and butterflies of our alpine regions appear as somewhat altered species only, being of the same genera as those of moderate and lower elevations. Every insect species of the highlands resembles its near rela-

tion of the lowlands. The *Carabus alpinus*, for instance, still frequently found in Engadine in the snow region up to 8500 feet, is, according to the opinion of the best entomologists, scarcely a particular species, but only a variety of the *Carabus sylvestris* of the lower region. *Cychnus pygmaeus* and *C. granosus*, at heights of 6000 to 7000 feet, are, although stunted, identical with the *Cychnus rostratus* of the high-lying plains of Bavaria. All alpine Lepidoptera of the genera *Colias*, *Hipparchia*, *Plusia*, and others, recall certain similar forms of the plains. The already mentioned *Euprepia flavia* in the highlands of Upper Engadine has its nearest relation in the *E. villica* found at the southern foot of the Alps, from which it is most probably descended. Every unprejudiced observer, even a systematic opposer of the transmutation theory, when comparing the larva, pupa, and imago of *Gastropacha arbuscula* at a height of 4800 feet to 5600 feet, with the several metamorphoses of *G. lanestris* or *G. crataegi* at the foot of the Alps, must involuntarily be struck with the idea that this alpine species is just as likely to be descended from a stray emigrant of the last-named species (through slight modifications, consequent on altered conditions of life and isolated local selection), as the alpine hare (*Lepus variabilis*) from the wild rabbit, which it so strongly resembles in the formation of the skull.

We might adduce numerous other instances of insects of all orders, to prove how exactly in the case of the most nearly related species, the stations are close and sometimes even contiguous, yet the boundary lines widely divergent. These phenomena would be inexplicable without we assume the influence of migration on selection. Every reflecting zoologist who is not satisfied with a sterile systematism, and particularly every entomologist who is not exclusively a collector and maker of species, but has preserved a keen unprejudiced eye for the remarkable laws of geographical distribution, will surely agree with me.

The law of migration of organisms and natural selection are closely connected. The geographical distribution of forms could not be explained without Darwin's theory. On the other hand, selection without the migration of organisms, and without long isolation of single individuals from the station of their species, could not be called into action. Both phenomena are in close correlation.

This law may throw a new light on the paleontology of the earlier geological periods, when geologists and paleontologists, in the possession of more abundant materials than the richest collection of the present time can offer, occupy themselves with the comparative and more minute study of the geographical distribution of all related fossils of the same period. As yet

but little has been accomplished in this respect. Dr. Karl Mayer, a thorough connoisseur of the tertiary conchifera, believes he can show all transitions, in the Darwinian sense, in the case of certain species of the genus *Turritella*.

Migrations in consequence of the struggle for existence and propagation, and the settling of emigrants far from the station of the original species, must, at those earlier epochs of the world's history, far more than at the present time, have favoured frequent modification of form. Grand geological changes, such as the emerging of islands and upheaval of whole continents, must have materially changed the conditions of life, at a time too when human action opposed no barrier to the free migration of organisms. The rarer occurrence and gradual disappearance of numerous species of the early world in the upper and lower strata of all formations, are also most probably closely connected with the law of migration as already explained.

Adaptation to changed conditions of life and transformation appear to be tantamount to a renovation. Species which did not migrate, and consequently did not alter in form, gradually became extinct. Invariability was their ruin.

The same law that has obtained in the history of nature for untold ages, is equally applicable to the

history of civilized states during the last few thousand years. Man, whose form, from a physiological and morphological point of view, is indisputably the most highly developed of the class Mammalia, was, during his long prehistoric periods of development, subject to the same law. A few individuals, instigated by a desire to improve their circumstances, migrated to countries far from the extreme limits of the station of their race; under favourable circumstances, through complete isolation they became adapted to the new conditions, and each slight change being continually inherited and enhanced, they became the progenitors of a new race or sub-race.

All high mountain ranges have been of the greatest importance in the ennobling of the human race. On heights and plateaux or in confined valleys, single pairs or families, more active and intelligent than their contemporaries, could more easily isolate themselves than in the plains. The hard struggle for life under these topographical and climatic conditions must have improved the physical and mental capacities of the successful competitors; advantageous variations were inherited by their descendants, of whom only the vigorous survived, as it is probable that at that time dull or weakly individuals soon died off.

How significantly the legendry of all parts of the globe points to mountain ranges as the cradle of all

the oldest civilized races! The Himalaya, Kueng Lung and Thian of the Mongolians, the Ararat group and Armenian Taurus of Semites, the Hindu Kush, the mountains of Iran and the Caucasus of the Aryans, were not only original centres of civilization, but ultimately starting points for the migration of conquering races. In eastern Africa the highlands of Nubia and Abyssinia, in the north-west the Atlas range, in America the highlands of Mexico, Peru, and Cundinamanka, have produced more powerful and intelligent races than the plains; and these cases are precisely analogous to the preceding.

The colder climate of these mountainous countries had only indirectly an ennobling influence on the corporeal and mental development of their inhabitants. The real cause lay in the fact that single families could more easily separate themselves, and found a new race which would remain undisturbed by frequent crosses with the original stock.

Thus we perceive that mountains were advantageous to the ennobling of the human race. By the migration and isolation of a single pair, experimental stations for natural selection were established; but these were only in a limited degree favoured by the climate, inasmuch as the emigrants could not live on roots and fruits only, but were obliged to have recourse to fishing and the chase. Mind and body were thereby

forced into greater exertion. Increased corporeal or mental powers are always inherited in a certain degree by the descendants, who may enhance them by constant exercise. The implements of wood, stone, or bone invented by savages, and their little practical artifices, became, together with improved powers of speech, heirlooms of isolated families, which under favourable circumstances developed into new stocks or races.) L^{an}

If our view is correct:—that only by the isolated migration of single individuals from the station of their species, natural selection could and can be effected, and that only by this means new varieties of plants and animals could arise in the past as well as in the present (in the latter case certainly more rarely on account of the difficulties opposed by civilization):—then the most serious objections as yet brought forward against the Darwinian theory are completely set aside.

Bronn, in his translation of Darwin's work, has thought it necessary to lay particular stress on the objection, that according to the theory of natural selection innumerable intermediate forms, as unpronounced as the varieties of our present system of zoology, would exist, and that all organic forms would be fused into an inextricable chaos.)

This objection is only tenable by our assuming that natural selection is, and must always be, active, with

or without the migration of individuals. But the existence of "innumerable intermediate forms" cannot be expected, if, through the isolation of emigrant individuals, natural selection continues to operate under the influence of altered conditions of life. By the undisturbed and isolated selection of colonists organic changes, which are always adapted to surrounding conditions, must necessarily accumulate. Many intermediate forms could only be preserved, if the new station were not protected by natural barriers, or by great distances, from frequent invasions of the older stock. If such invasions were rare, and the invaders few in number, then the variety or incipient species would be but little disturbed in its formation, more especially if the latter were at an advanced stage. It is a peculiarity of almost all animals in the natural state that nearly-related species avoid intercourse, and almost invariably show greater natural aversion than more distantly related forms.

In countries where neither natural barrier, such as a river or mountain range, nor a considerable intervening space, secures the isolation of the emigrant, and where, in consequence, the frequent influx of the old species admits of free crossing and intermingling, an incipient variety will either return to its original form, or numerous gradations will arise, as is in reality the case with certain species of Coleoptera

inhabiting the slopes of our Alps. An experienced entomologist, H. von Kiesenwetter, formerly an opponent, now an adherent, of the theory of transmutation, recently pointed out in a remarkable essay in the 'Entomologische Zeitschrift' these numerous transitional forms of the alpine genus *Oreina*.

Another objection of Darwin's opponents is as easily set aside by the law of migration, in conjunction with natural selection:—"If," say they, "natural selection is a necessity, and has been uninterruptedly in operation from time immemorial, how is it—the existence of spontaneous generation being extremely doubtful—that the lowest organic forms still exist? Why were not our Infusoria, Foraminifera, and Bryozoa, our Algæ and Lichenes long ago converted into higher forms?"

Our answer is simple. Natural selection is not in itself an unconditional necessity, but is dependent on migration, and geographical isolation during a long period, together with altered conditions of life. Organisms which never leave their original station, will alter as little as certain others, on which nature has bestowed somewhat too considerable powers of locomotion. To the latter belong the so-called cosmopolitan species. Plants growing on the sea-coast, the seeds of which are easily transported by currents; Cryptogams, the spores of which are carried with such

facility by the wind ; even many phanerogamous plants with winged seeds, are often as species widely distributed. It is the same with many animal species. The tiger and the brown rat, the stork and the swallow ; among nocturnal birds, the screech owl ; among insects, the widely distributed butterfly (*Vanessa Cardui*), the common flea, and many others, appear everywhere unaltered, because, on account of continual crosses with sporadic settlers of the same species, a lasting isolation of colonists, and with it natural selection, is impossible.

A third objection to the theory, upon which M. Käferstein of Göttingen, not so very long ago, thought it necessary to lay great weight, is certainly the weakest of all. Instead of answering his purpose, it serves to prove our view. In the Pyramids and caves of Memphis and Thebes mummies of the sacred Ibis (*Ibis religiosa*) as well as of crocodiles, have been discovered, which are said to date as far back as the time of King Rameses I., but which are, at all events, some thousands of years older than the commencement of the Christian era. These dried-up specimens exactly resemble those existing to this day on the Upper Nile. “Now if,” say Darwin’s opponents, “natural selection is always at work, how is it that these species have not altered in the slightest degree during 4000 years?” We ask, how could it be

otherwise? The valley of the Nile is geographically cut off. The Ibis and crocodile are stationary on the Nile, are only to be found there, never wander, and consequently never change their conditions of life. Where there is no migration, that is where no isolated colony is founded, natural selection cannot, as previously stated, take place. The crocodiles of the Niger or the Ganges are, on the other hand, as different from the crocodile of the Nile as the alligators of the several rivers in tropical America are different from each other; the latter have in fact been described by some naturalists as so many distinct species. Had the Ibis and crocodile of the Nile become altered in spite of being subjected to an unchanged mode of life, our theory would indeed have proved false.

The law of migration, by reason of which all organisms strive to increase the limits of their station, in order to maintain the struggle for existence with all other beings, but especially with those of the same species, is deeply rooted in the nature of things. By increased civilization the effect of this law must have undergone very considerable modification.

The freedom with which most animals before the human era, even so recently as the tertiary period, were able to exercise their powers of migration, received a serious check when man, with superior intelligence, with artificial weapons and implements prepared by

no other animal, appeared as competitor in the struggle for existence. With the spread of the human race, and its increased powers of annihilating other beings, or of causing them to multiply for his own benefit, the distribution of organisms by migration became, in comparison with earlier periods, extremely confined, and partly dependent on his will. Natural selection must consequently have become incalculably limited.

Few of the larger terrestrial mammalia of any country have the power, as formerly, of extending the boundaries of their stations by voluntary migration. Races which support themselves by the chase have for ages occasioned the diminution of all mammals which serve them for food and raiment; pastoral and agricultural races destroy in as great a degree all animals obnoxious to themselves. Mammals and reptiles, and in a somewhat less degree birds, insects, crustaceans, mollusks, and so forth, in fact nearly all terrestrial animals, are therefore, since the increase of the human race, to a certain extent dependent on man for their existence. Even the passive distribution of seeds has not a little diminished in comparison with earlier times. In garden, meadow, and field, man wages eternal warfare against all intruders, and where extirpation is impossible, he at all events limits their number, and checks their distribution.

The distribution of weeds and parasites, of animals

of prey and poisonous reptiles, in short, of all organisms which man does not protect or tolerate, has diminished since the spread of civilization. The migration and isolated colonization of wild vegetable and animal species in all countries inhabited by man, is now extremely difficult.

The earlier geological periods, during which the present race of men certainly did not exist, were far more favourable to natural selection. Frequent and extensive rending of the then thin crust of the earth, and great submarine upheavals of molten masses of rock, must frequently and suddenly have changed the physical and chemical properties of the sea in different regions. This, in all probability, must have resulted in emigration on a grand scale, and afterwards in the return of the marine inhabitants. These numerous migrations, dislocations and sporadic distributions, promoted natural selection and the variations of those marine organisms which had been driven away or were leaving the station.

At a later period, on the emerging of numerous oceanic islands, these afforded so many experimental stations for the natural selection of land and fresh-water animals, and moreover opposed a barrier to the wanderings of marine creatures. In this manner the multiplicity of form of terrestrial organisms was favoured in a considerable degree.

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The most fruitful epoch for natural selection was probably during the two first periods—the Eocene and the Miocene—of the tertiary formation; when islands, subjected to subterranean elevating forces, gradually merged into continents of very different relief; whereby a vast area, the grandest field for natural selection and the formation of types, was afforded to the passive migration of plants, to the free motion of terrestrial animals, and to their sporadic settlements; and all this under conditions of life as new as they were manifold. It is also probable that the struggle for existence of the different organic forms reached its greatest height during the immeasurably long periods of the tertiary formation.

In the Pliocene period, and perhaps even towards the end of the quaternary deposits of the diluvium, the circumstances favourable to natural selection were fewer. Volcanic action, confined to a small space, was less intense than formerly; fewer islands were upheaved, and no continents. A stimulus to the extensive migrations of animals and plants was wanting after the return of the organisms dislodged by the boulder drift. That juncture in the geographical distribution referring to beings had now arrived, of which Humboldt says, “after a long struggle and many fluctuations, a state of equilibrium was established.”

It was about this time that man appeared on the scene as the most formidable competitor of the animal world. The gradual perfecting of his primarily very rude civilization still further limited geographical distribution, and considerably modified the effect of natural selection. But in place of the latter there arose a mightier and more rapid instrument of change—the artificial selection of animals and plants.

A further consequence of advancing civilization must be the more frequent extinction of wild species. With the exception of such organisms as find refuge in primeval forests, high mountains, uncultivated steppes or deserts, and adapt themselves to such new conditions, only those terrestrial forms will survive which man protects or fosters for use or pleasure, especially those belonging to the higher classes of both kingdoms. Natural selection, at all events in habitable tracts, will finally almost entirely cease, and give place to artificial selection.

New races of men will no longer arise, but only bastard ones, through the frequent intercourse of existing races. Perfect isolation of single stocks during a long series of generations is now no longer possible, on account of the present state of universal intercourse and of the stream of emigration arising out of the over population of the civilized countries of Europe and Asia; so that there now lacks the fundamental

diffusion

condition for the formation of new races. Neither continent nor island can in future be exempt from the invasion of settlers or intercourse with Europeans. In Mexico, Central America, and in most South American States, a bastard race, half European, half Indian, constitutes the greater part of the population ; and in Hayti the mulatto population amounts to a third of the whole.

But with the formation of bastard races, fresh national types will be introduced and fixed, perhaps in a still greater degree than formerly, for every degree of political as well as geographical separation, such as differences in rank, religion, and nationality, which are nearly all habits and customs of civilized society, is favourable to the formation and perpetuation of certain types.

It is very often difficult in describing them to give to each national type its particular anthropological expression ; but the eye frequently distinguishes at a glance general physiognomical features, which we are unable to render in words. An experienced eye can, for instance, not only distinguish Jew from Christian, but also the Frenchman from the Italian, the American from the Englishman, and even the North from the South German. But it is not only certain physiognomical characteristics of nations which gradually become stereotyped, for we find similar

recognizable types in certain ranks of life, the individuals of which only intermarry with those of the same caste, and even in dynastic houses which for a series of generations have frequently intermarried. Thus, amongst the Hindus every caste has its peculiar physiognomy. But all these well-marked types have been gradually acquired entirely by a certain degree of isolation; or in other words, by prohibiting the intermingling of individuals of different creeds, nations, ranks, or families. But such features are recognizable only by keen observation, and are traceable to the same cause which gives rise to varieties in animals, with the sole difference that in civilized life separation from the mass is secured by social custom, and consequently does not necessitate isolation, whereas, in savage life, material barriers are necessary for the isolated selection of individual characteristics.

Probably new national types will arise in all colonies, particularly in North and South America, Australia, New Zealand, and similarly situated countries, on account of the intermingling of settlers; but such national types are merely slight morphological differences, compared with the decided differences of true races.

Since the above views on the causes and results of the law of migration were discussed—much more generally than now—during the sessions of the Royal

Academy of Sciences, I have received many favourable criticisms from various quarters. A clever naturalist, well acquainted with the leading facts of geographical distribution, finds in this law "the filling up of a considerable gap in Darwin's theory of transmutation, and the removal of many objections to it, as well as the key to a satisfactory explanation of most enigmatical phenomena in the distribution of animals and plants on the earth's surface." And Darwin himself remarks in the letter with which he honoured me, "that many difficulties and objections to his theory had been set aside by the law of migration, in a manner which had never even occurred to himself."

On one certainly very important point, and one only, does Darwin still disagree with me, *viz.* as to whether the isolation of emigrants of the animal or vegetable kingdom is merely useful to the continued formation and fixing of individual characteristics, or whether it is a necessary condition.

Darwin thinks that on many large tracts all individuals of the same species became gradually changed, just as the English race of horses becomes changed, by continued selection without isolation of the most suitable individuals. He, however, allows that by geographical isolation new species may have been formed contemporaneously with the alteration of the older stock, and adds, that a certain degree of separa-

tion, although not absolutely necessary, must be at all events beneficial to the formation of species, and that in this respect the facts and views communicated by me are of great value. I gratefully acknowledge the latter admission; I think, however, I am justified in maintaining my view, that without the isolation of a few individuals from the station of their species, natural selection can as little take effect with wild, as with domesticated individuals, and that without this separation the continued formation and perpetuation of individual characteristics is impossible.

The most weighty arguments in favour of my views are to be found in those interesting facts, communicated by Darwin himself, on the results obtained by the artificial selection of domesticated animals and plants, which were only satisfactory when those under treatment were carefully selected and separated from the old stock.

The experience of all stock breeders in countries where cattle and sheep live together in a half-wild state, as in the steppes of Russia, the pampas and llanos of the Argentine Confederation, and the numberless small savannahs of the western provinces of Central America, further speaks in favour of the necessity of isolation.

In all parts where these natural pastures abound, and where herds graze indiscriminately, we meet with

exceedingly uniform breeds. Every freshly imported superior race of cattle, if not kept apart, degenerates after a few generations into the native breed, without altering it.*

All possessors of haciendas in the rich cattle districts of Chiriqui, Guanacaste, and the Pacific seaboard of the state Guatemala, assured me that within the memory of man no alteration in the cattle of the savannahs had been perceptible, in spite of several attempts to improve the breed. In their opinion the cause lies in the universal custom of allowing the herds to graze over a large tract, and the difficulty of separating individuals suitable for breeding purposes. The advantage of superior strength in selected bulls or stallions was, on account of free intercourse, utterly useless, as they were unable to prevent the far more numerous individuals of inferior breed from also attaining their object. These remarks concerning the impossibility of improving the breed of horses if selected pairs are not separated, are confirmed by the cattle breeders in the steppes of southern Russia.

The case is certainly somewhat different in the Paramos of the equatorial Andes. When visiting the great stock farm of Llangagua on the northern slope of Chimborazo, where I had the opportunity of being pre-

* The choice horses possessed by the wealthy inhabitants of Buenos Ayres, Monte Video, &c., are kept in stalls or enclosed fields, and are therefore isolated and better fed.

sent at the yearly "Rodeo" (the collecting of the half-wild herds for the purpose of branding new arrivals), I was greatly astonished to see a far finer breed than in other parts of the plateau of Quito or of the lower tracts. This fact is to be accounted for, not by the more nourishing food afforded by the Paramos grasses, but by the circumstance that the herds break up into small sections on the slopes and terraces, and in the valleys and barrancas of the Chimborazo. These sections are called "atazos." Each atazo, consisting of about thirty to forty individuals, is led by a bull of superior strength, who drives away all weaker rivals.

The topography of the ground favours this local separation. I was informed by the owners of haciendas on the beautiful potrils or mountain pastures, which rise step-like on the south-west side of the extinct volcano of Chiriqui, in Central America, that their experience was quite the same. The more powerful breed of cattle is to be ascribed materially to the isolation of small herds headed by the strongest bulls, at different heights of this colossal group. Still, in the opinion of their owners the breed would be much improved, if it were possible to exclude all smaller and weaker bulls, which from time to time break into the herd.

Now, if these observations, in countries where cattle are kept in a half-wild state, coincide with the results

obtained by artificial selection : that only by the separation of individuals of both sexes favourable variations may be preserved : we may safely assume that similar conditions obtain in the case of animals in a wild state, and that without local isolation, the preservation of inherited characteristics is highly doubtful.

But, if the continued selection with systematic pairing of two unusually powerful and well-matched individuals, has the same meaning as that which follows from Darwin's remarks, it is a process which can only operate in civilized countries. By artificial selection alone, is it possible in this way to change or improve the breed.

Each artificial improvement, each selection of well-matched individuals, is combined with a certain degree of isolation and restraint. Had the English breed of race-horses always been kept in herds and unselected, it would certainly have altered as little as the half-wild herds of the pampas and savannahs of South America.

The careful pairing of well-matched individuals, the "foundation and corner-stone of the principle of selection," can only take place in the case of domesticated animals and plants assisted by man, and never without local separation.

The assumption of the continued selection of choice individuals for many generations, in conjunction with

the unlimited intermingling of wild or half-wild animals is, in my opinion, a profound error. The invariable consequence of free crossing is, I repeat, uniformity; and the experiences of the artificial selection of animals and plants, communicated by Darwin in his latest work on the subject, are directly contradictory to the assumption of natural selection without isolation.

The impulse of animals to migrate, a natural consequence of increased competition between individuals of the same species, is, we repeat, a primary cause of the enhancement of individual varieties, through altered conditions of life. Lengthened separation from the former home results in the preservation of certain organic variations, provided they are adapted to the requirements of the new settlement. The longer the series of variations, and the less it is disturbed from without, the more decided will be the characteristics of the new species. It is highly probable, that in earlier times, high mountain ranges and broad rivers did not most contribute to the isolation of emigrants. Well-wooded lower regions, easier to surmount, and rivers of moderate breadth, probably promoted this important process in a much greater degree; still, the latter could not have permanently marked out the boundaries of very nearly-related species so decidedly as the former, for they did not oppose so difficult a barrier to the gradual spread of the older form,

nor to the return of the younger. Inferior obstacles, such as watersheds of moderate height, might, at a time when continents were but sparsely inhabited, have secured the isolation of emigrant colonies sufficiently to complete commencing varieties, and to render them permanent. This once accomplished, the fact that individuals of a species avoid pairing with those of another nearly related, would suffice to protect the younger form from the older, even though the former, by returning to its original haunts, became no longer geographically separated from the old stock. In the western prairies of North America I never remarked different species of deer in the same herd, and other travellers have made the same observation in regard to the different species of antelopes in Africa. It is equally well known that elephant and rhinoceros, fox and jackal, jaguar and puma, but most strikingly of all the nearly-related genera and species of monkeys, avoid each other with most decided aversion. The gorilla to the north of the Gaboon, and the chimpanzee south of that river, notwithstanding their near relationship and the proximity of their abodes, never associate.

The remarkable antipathy of nearly-related species is a most significant feature in the life of organic forms, for it evidently serves as protection to every new species. For this reason transformation through

slight individual variability into a distinct race is, in our opinion, impossible without separation from the station of the species, where no aversion protects single instances of variability against frequent crosses, or from relapsing into the old type.

Whilst nearly-related races avoid each other with hatred and disgust, a slight degree of individual variability appears to act rather as an attraction. All pigeon fanciers know that slightly different pigeons—for instance those somewhat different in plumage—readily pair, whilst pigeons of two distinct kinds, such as pouters, fantails, and so forth, if left to their free impulses, almost always seek out individuals of the same kind, and can only be brought to pair by compulsion, that is, by temporary separation from their species.*

Those who with Darwin deny the necessity of isolation for natural selection, and only admit its advantage, must indicate another cause for the first stimulus to increased variation, and other conditions upon which the preservation of the new characteristics depend.

* In the human race there exists a corresponding trait. Fair northerners of the Aryan stock, with blue eyes, evince and feel no aversion to the black-eyed brunettes of the south; dark-eyed, black-bearded southerners of the Romanic branch appear by no means displeasing to the fair Germanic women; but Europeans have never been known to be attracted by Hottentots, Negroes, or Esquimaux. Scarcity of women of the same race is the sole cause of the bastard races of the West Indies and South America.

Without the assumption of this condition all enigmatical facts in the distribution of animals and plants would remain as doubtful as before, whereas they are easily explained by the law of migration. Moreover, the above-mentioned objections to the theory of natural selection would remain in full force; for, if we assume that it may and does transform species without this condition, we ought to find numerous transitional forms for every species, which in nature are either not to be met with, or are only to be found where the contiguous haunts of these sporting species have no natural barriers.

Further, the continued existence of the lowest animal and vegetable forms is not compatible with natural selection as a necessary condition, without isolation of emigrants. Even the invariability of animals in the geographically enclosed valley of the Nile for upwards of 4000 years would remain a serious objection, easily set aside by the law of migration.

Individual power of transformation is therefore, according to our conviction, everywhere and always dependent on isolation in order to have lasting effect. Without separation from the home of the species, this wonderful capacity of the organic form, the fundamental cause of innumerable types, would be without value, because its effect in the old station would be completely neutralized.

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In conclusion, I will briefly sum up the foregoing views—based on numerous well-known facts in the geographical distribution of organisms—of the extremely simple process by which nature produces typical differences, and determines the geographical distribution of forms.*

The competition of all beings for space, food, and reproduction, or the “struggle for life” so appropriately named and illustrated by Darwin, gives the first impulse to migration. Vegetable seeds wander by passive migration, that is to say, are transported by winds, rivers, seas, or animals. Birds, insects, and other animals generally wander of their own accord far from the station of their species; arrived in new localities, where they maintain the struggle, especially for food and reproduction, under somewhat altered conditions of life, their individual variability receives fresh stimulus; then, through uninterrupted activity of the same causes, the organic variations must accumulate during a series of years.

The form and degree of variation in an organ will depend for the most part on the physical conditions of the new home, configuration of the ground, climate, food, and the never-failing competition with other species.

* The scientific reader is requested to excuse these frequent repetitions; perhaps they may serve as a means of more complete comprehension to those who are not naturalists.

If the natural barrier or intervening space is insufficient to protect the colony for a long time from frequent invasions of the old stock, the incipient variety will again retrograde into the old form ; but if the contrary is the case, it will become a so-called permanent variety (race) or new species.

Whether the boundaries are lasting, or whether they again disappear—on account of the gradual invasion of the old stock, or the partial return of the younger species,—depends on the obstacles opposed by the natural barriers separating the younger from the older species. Probably the latter process has generally been the case, when the emigrants only passed over low mountain ranges or small rivers.

The more frequent upheaving and sinking of the earth's crust in the earlier geological periods, doubtless occasioned more frequent and numerous migrations of marine animals, the separation of the Fauna and Flora of different seas, and the independent development of forms in separate and confined basins. Paleontological experience teaches that all confined sea basins, as, for instance, the lithographic slate of Solenhofen and Pappenheim, and the Glarner slates, possess peculiar species of fishes, crustaceans, &c., the types of which indeed call to mind generic forms of other formations of the same epoch, but are at the same time specifically different.

In earlier ages, the more frequent cleaving of the earth's crust and the existence of numberless islands undoubtedly favoured, together with isolation, the development of manifold forms, especially of the earlier amphibia and of more recent mammalia. The most favourable conditions for the operation of natural selection were afforded in the two more remote and long periods of the tertiary formation ; when, through gradual but extensive elevation, islands merged into continents, thus opening out to organisms a large field for the struggle for existence, and for the exercise of migration.

With the commencement of human increase and civilization begins a new epoch for selection. The facility of migration decreases ; undisturbed isolation is more difficult ; and opportunities for the formation of varieties become fewer.

Civilized man limits to his own use the migration of organisms and the previous law of free colonization, by inventing, through his superior intelligence, the most formidable means of annihilation. He destroys obnoxious animals and plants ; fells and burns forests ; extirpates or reduces the number of animals of the chase ; and only suffers or protects such animals or plants as afford him food and raiment. Artificial selection takes the place of natural selection, which diminishes more and more with increasing civilization.

If the questions submitted by Alphonse de Candolle as the problem of the natural history of our century have not all received a sufficiently satisfactory answer, still, with Darwin's transmutation theory, a new light has fallen upon that portion of creation which for a long time had remained a mysterious secret.

I will now endeavour, in three short propositions, to formulate the simple causes or laws which have "geographically limited the form and fixed its typical characteristics."

1. The greater the change in the conditions to which individuals are subjected on emigrating to another territory, the more intense must be the inherent individual variability of each organism.
2. The less the even tenor of this increased individual variability of organisms is interrupted by frequent crosses with emigrants of the old stock, the more frequently will nature be successful in forming a new variety or incipient species, by the accumulation and inheritance of fresh characteristics.
3. The more advantageous to the variety, the change in each single organ, the better it will be able to adapt itself to surrounding circumstances; and the longer the selection of an incipient variety of colonists remains un-

disturbed by the old stock, the more frequently will a new species arise out of the variety.

The greatest thinker of Grecian antiquity said more than 2000 years ago that "the fundamental principles of all nature are change and motion; whoever does not recognize this does not know nature."

Aristotle thus significantly pointed out, although without certain knowledge, the true fundamental principle, applying equally to the fashioning of organic forms, and to the forces regulating the heavenly bodies, which are based entirely on mass and the distribution of ponderable matter and its powers of attraction. Motion necessarily begets change!

Humboldt foresaw the twofold effect much more distinctly than Aristotle, when he wrote the passage quoted in the introduction, on form and its typical differences. Borrowing his own words, we might briefly describe the law of transmutation thus:—The geographical isolation of the form, a necessary consequence of migration, is the cause of its typical characteristics.