
ART. II.—ISLAND LIFE.

Island Life—or The Phenomena and Causes of Insular Faunas and Floras—Including a Revision and attempted Solution of the Problem of Geological Climates. By ALFRED RUSSEL WALLACE.

AN essentially modern problem, which may be described as still awaiting solution, is that which concerns the origin and distribution of life upon our globe. The theory of Darwin, that all animal life is the result of the development of a few protoplasmic germs, aided by natural and sexual selection, is now generally accepted by men of science, as that which most nearly meets the requirements of recent discoveries in geology and zoology, elucidating, to a certain extent, the perplexing facts in the history of long buried, and as yet only imperfectly recovered records, preserved for us in the rocks and gravels beneath our feet; as well as those which every student of anatomy and embryology must encounter in the course of his studies. For it has come to be acknowledged that animal and vegetable life as at present existing, cannot be separated by a vast gulf, as was once supposed, from the former life of our planet, but that in many instances, fossil forms, only slightly modified, are found to exist as living species in remote regions, where they have remained undisturbed by that struggle for existence, which has caused the extinction of so many species, not only in early geologic but even in modern epochs.

It is this fact which renders the study of Island Life peculiarly interesting and instructive, for it is obvious that islands, separated as most of them are by many hundreds of miles of deep sea from the nearest continent, would be less likely to be overrun by new species than the continents—connected as all of these are by isthmuses, or separated by straits so narrow, as to offer no insuperable obstacle to the emigration of some species—and would, therefore, be more likely to retain the animal and vegetable forms received in the first instance, either through ancient connection with some continent, or by some accidental transoceanic emigration from distant lands, repeated from time to time.*

The difficulties which beset an enquiry such as that undertaken by Mr. Wallace, may be better appreciated by a brief reference to two or three of the singular facts which present themselves in the geographical distribution of animals.

It would be natural to suppose that the animal and vegetable life of islands would in all cases resemble that of the nearest continent, slightly modified perhaps by changes in the environment, and always wanting in such of the larger mammals as were unable to cross the intervening seas. But although this holds good to a certain extent with regard to some of those islands classified by Mr. Wallace as continental, it is by no means universally the case. The most noteworthy perhaps of the islands as regards the anomalous character of its fauna and flora is Madagascar, which, judging from its position, we should look upon as peculiarly and exclusively African, and yet we find that although it possesses *some* African forms, yet the majority of its fauna and flora resemble more nearly American and West Indian forms, with affinities in the Miocene fauna and flora of Europe and Asia. Again the peculiarities of the fauna and flora of Australia are well known, but the nearest congeners of the curious marsupial mammals of that antipodean land are found among the fossil remains of Europe, whilst as Mr. Wallace says:—

"Let an inhabitant of Australia sail to New Zealand, a distance of less than thirteen hundred miles, and he will find himself in a country whose productions are totally unlike those of his own. Kangaroos and wombats there are none, the birds are almost all entirely new, insects are very scarce and quite unlike the handsome or strange Australian forms, while even the vegetation is all changed, and no gum-tree, or wattle, or grass-tree meets the traveller's eye."†

That mere proximity does not cause identity in the productions of adjacent islands is shown in many instances, the most remarkable, perhaps, being that of the islands of Bali and Lombok in the Malay archipelago, separated

* "There are," says Sir Joseph Hooker, "only two possible hypotheses to account for the stocking of an oceanic island with plants from a continent; either seeds were carried across the ocean by currents, or the winds, or birds, or similar agencies; or the islands once formed part of the continent and the plants spread over intermediate land that has since disappeared."—*Lecture on Insular Floras*, by Sir J. D. HOOKER.

† "Island Life," p. 4.

by a strait only fifteen miles wide at its narrowest part.

"Yet these islands differ far more from each other in their birds and quadrupeds than do England and Japan. The birds of the one are extremely *unlike* those of the other, the difference being such as to strike even the most ordinary observer. Bali has red and green woodpeckers, barbets, weaver-birds, and black and white magpie robins, none of which are found in Lombok, where, however, we find screaming cockatoos and friar-birds, and the strange mound-building magapodes, which are all equally unknown in Bali. Many of the kingfishers, crow-shrikes, and other birds, though of the same general form, are of very distinct species; and although a considerable number of birds are the same in both islands, the difference is none the less remarkable—as proving that mere distance is one of the least important of the causes which have determined the likeness or unlikeness in the animals of different countries." *

These two islands have long been associated with Mr. Wallace's name, the strait which divides them having been termed Wallace's line, remarkable as cutting off abruptly the fauna and flora of the Malay archipelago from that of the Australian continent and islands, the most singular point about this sudden change being the diversity in the *birds* of the two islands, because of all terrestrial creatures birds would seem to possess the greatest facilities for locomotion, and to most of them fifteen miles would be only a short flight. Nevertheless it is one of the curious and anomalous facts brought to our notice in this inquiry, that those creatures which seem the least capable of wide distribution are exactly those which are most cosmopolitan; such are beetles and land shells, which, although they may be few in number and peculiar in species on some of the islands, yet have commonly affinities in every part of the world. Mr. Wallace shows also that *climate* has less to do with changes in fauna and flora than is usually supposed. He says:—

"Hot countries usually differ from cold ones in all their organic forms; but the difference is by no means constant, nor does it bear any proportion to difference of temperature. Between frigid Canada and sub-tropical Florida, there are less marked differences in the animal productions than between Florida and Cuba, or Yucatan, so much more alike in climate, and so much nearer together. So the differences between the birds and quadrupeds of temperate Tasmania and tropical North Australia, are slight and unimportant as compared with the enormous differences we find when we pass from the latter country to equally tropical Java." †

These are only a few of the instances given by Mr. Wallace to prove that neither distance, nor difference of climate, can be looked upon as a guide in tracing the distribution of animal and plant life on the globe, and if we look to geology to help us the task appears to become still more complicated, since the nearest congeners of the peculiar fauna and flora of the Australian continent are found in the Miocene deposits of Europe, whilst the ancestors of the horse and camel are specific to America, where neither existed at the date of the visit of Columbus.

But notwithstanding the anomalies of distribution apparently so numerous, it has been found possible and convenient to map out the world into various zoological regions, corresponding to a certain extent with the geographical regions, the classification now generally adopted being that of Mr. Sclater, which is as follows:

Region.	*Geographical Equivalent.*
Palæarctic	Europe with north temperate Africa and Asia.
Ethiopian	Africa (south of the Sahara), with Madagascar.
Oriental	Tropical Asia to Philippines and Java.
Australian	Australia with Pacific Islands, Moluccas, &c.
Nearctic	North America to North Mexico.
Neotropical	South America with tropical North America and West Indies.

These regions, although they may to a certain extent overlap just at the boundaries, yet mark out fairly the present divisions in the distribution of animal life on the globe; but, as may be seen from the instances we have noticed above, these divisions cannot be extended beyond the present or most recent geological period, since if we go back to the Miocene, not only do we find great changes in the distribution of existing species, but an abundance of strange forms, having at present no representatives. Now, the two things requisite to reconcile these facts with the Darwinian theory, would seem to be, enormous changes in the distribution of land and water, and unlimited time. We are, therefore, somewhat startled to find that Mr. Wallace, who is not only a devout believer in the Darwinian theory, but a fellow-worker and codiscoverer with Mr. Darwin of the important bearing of the theory of evolution upon the origin of species, should to a certain extent deny the necessity for both these factors, commencing his inquiries by declaring his belief in the fixity of the great continents, and announcing that, according to his judgment, the time required by geologists for the formation of strata is much too long. It is true that when we come to examine what he means by the permanence of the continental areas, we are somewhat reminded of the sailor's knife, which, after having had two new handles and three new blades, was yet cherished as the original knife, for he says,—

"It will be observed that the very same evidence which has been adduced to prove the *general* stability and permanence of our continental areas, also goes to prove that they have been subjected to wonderful and repeated changes in *detail*. Every square mile of their surface has been again and again under water, sometimes a few hundred feet deep, sometimes

* "Island Life," p. 4. † Ibid. p. 5.

perhaps several thousands. Lakes and inland seas have been formed, have been filled up with sediment, and been subsequently raised into hills, or even mountains. Arms of the sea have existed, crossing the continents in various directions, and thus completely isolating the divided portions for varying intervals. Seas have been changed into deserts and deserts into seas. Volcanoes have grown into mountains, have been degraded and sunk beneath the ocean, have been covered with sedimentary deposits, and again raised up into mountain ranges; while other mountains have been formed by the upraised coral reefs of inland seas. The mountains of one period have disappeared by denudation or subsidence, while the mountains of the succeeding period have been rising from beneath the waves. The valleys, the ravines, and the mountain peaks have been carved out and filled up again; and all the vegetable forms which clothe the earth and furnish food for the various classes of animals have been completely changed again and again." *

It would, therefore, seem that all that Mr. Wallace means by the *Permanence of Continents* is, that large masses of land have always existed in the northern hemisphere, corresponding to a certain extent with the present continents, and having extensions southwards, resembling the Africa and South America of our present epoch. Mr. Wallace entirely rejects the idea of the existence of the fabled Atlantis, so firmly believed in by philosophers of old, and which has its adherents even in our own day; and he is still more sceptical with regard to the hypothetical Lemuria, which has found favour with many excellent geologists and naturalists of the modern school; nevertheless, in accounting for the facts of the distribution of life upon oceanic islands, he is obliged to enlarge the present area of most of those now isolated, and to hypothesize the existence of other large islands, serving as stepping-stones to continents, or to other islands; but such islands could never have served as stepping-stones to mammals, or even to birds, since, according to Mr. Wallace's own showing, fifteen miles of deep sea has been a sufficient barrier in the islands of Bali and Lombok to prevent any interchange of mammals; whilst even with the extension allowed to existing lands, there must have been in most cases a far greater width of deep sea between the islands and the mainland than in that typical example. It is certainly true that most oceanic islands are destitute of warm-blooded terrestrial mammals, but many of them possess reptiles, birds, and insects, the migration of which over deep seas appears almost as impossible as that of the larger mammalia; and, indeed, in accounting for the poverty of the British Islands in mammalia and reptiles as compared with the European continent, to which they were doubtless at one time united, Mr. Wallace says:—

"When England became continental, these entered our country; but sufficient time does not seem to have elapsed for the immigration to have been completed, before subsidence again occurred, cutting off the further influx of purely terrestrial animals, and leaving us without the number of species which our favourable climate and varied surface entitle us to. To this cause we must impute our comparative poverty in mammalia and reptiles—more marked in the latter than the former owing to their lower vital activity and *smaller powers of dispersal*." *

It therefore seems difficult to account for the existence of gigantic tortoises, lizards, and snakes on the Galapagos Islands, which are 600 miles from the coast of South America —a sea-depth of 2,000 to 3,000 fathoms intervening. Yet these reptiles are all supposed to have been derived from the American continent. There are also two species of lizards in the Sandwich Islands; but since Mr. Wallace denies the possibility of these oceanic islands ever having formed part of a continent, he is obliged to account for these and similar anomalies by chance migrations, aided by storms and oceanic currents.

In this theory of the permanence of existing continents and oceans, Mr. Wallace would appear to stand almost alone among geologists and naturalists; and it is easy to point out discrepancies in his arguments; nevertheless, it is fair to him to acknowledge that his views seem to be in general accordance with those of Darwin, and to be corroborated, to a certain extent, by the recent investigations of the *Challenger*, for in the recently published "Report of the Scientific Results of the Exploring Voyage of H.M.S. *Challenger*," vol. i., treating of that curious and interesting abyssal fauna which appears to occupy all ocean depths from 500 to 600 fathoms to the bottom, and to be of vast antiquity and great uniformity, Sir Wyville Thomson remarks:—

"I suppose I am now entitled to regard the view as widely accepted by geologists, that the age of the most obvious depressions in the crust of the earth which are now filled by the sea is much greater than we were at one time led to believe. I long ago expressed the opinion that the primary meridional grooves of the earth's crust dated from its original cooling; whether this be so or not there seems to be sufficient evidence that all changes of level since the close of the palæozoic period are in direct relation to the present coast-lines. There does not seem to be a shadow of reason for supposing that the gently undulating plains, extending for over a hundred millions of square miles at a depth of two thousand five hundred fathoms beneath the surface of the sea, and presenting like the land their local areas of secular elevation and depression, and their centres of more active volcanic disturbance, were *ever* raised, at all events in mass, above the level of the sea; such an arrangement indeed is inconceivable. If, then, such a condition did not at any time exist, a continuous ocean must always have extended over the greater part of the earth's surface, and must have occupied continuously any secular areas of depression due to the assumption by the world of its present physical features." †

* "Island Life," p. 99.

* "Island Life," p. 319.

† "Report of the Scientific Results of the Exploring Voyage of H.M.S. *Challenger*," vol. i. p. 46.

To this subject we shall return later, but will now proceed to speak of Geological time, the second point upon which Mr. Wallace's views are at variance with those of most geologists. Basing his arguments upon the calculations of physicists, and particularly on those of Sir William Thomson and Dr. Croll, as to the rate of the primary cooling of the earth's crust, which both these eminent men agree cannot have extended beyond 400 millions of years, Mr. Wallace proceeds to calculate the time required for the formation of the various sedimentary strata, and the rate of organic change on the surface of the earth; and considering that these must have been greatly accelerated by changes of climate, brought about by the varying excentricity of the earth's orbit, combined with the precession of the equinoxes, he fixes the "height of the glacial epoch at the period of high excentricity which occurred 200,000 years back, and that the next great period of very high excentricity, 850,000 years ago, fell within the Miocene epoch." "An earlier epoch of great altitude in the Alps, coinciding with the very high excentricity 2,500,000 years ago, may have caused the local glaciation of the middle Eocene period, when the enormous erratics of the Flysch conglomerate were deposited in the inland seas of Northern Switzerland, the Carpathians, and the Apennines."* Thus he estimates the duration of the Tertiary epoch at about four million years, and allows sixteen million years as the time elapsed since the Cambrian, according to Lyell, or sixty, according to Dana, and he believes the mean between these authorities—twenty-eight million years—to represent nearly the time, as calculated from the rate of denudation and deposition, at the same time reminding us that an approximation only can be attempted in a calculation such as this, adding—

"The only value of such estimates is to define our notions of geological time, and to show that the enormous periods, of hundreds of millions of years, which have sometimes been indicated by geologists, are neither necessary nor warranted by the facts at our command; while the present result places us more in harmony with the calculations of physicists by leaving a very wide margin between geological time, as defined by the fossiliferous rocks, and that far more extensive period which includes all possibility of life upon the earth." †

Twenty or twenty-eight millions of years, to those who have been accustomed to the six thousand of the Hebrew cosmogony as interpreted by Usher, would seem a time incomprehensible and altogether excessive, but, calculated by the theories of evolutionists, it appears an inconveniently narrow estimate. It is true that if we deduct twenty-eight millions from the one hundred million years which Sir William Thomson gives as his estimate of the probable age of the earth, we shall find seventy-two millions reserved for the period of chaos and the slow development of the low forms of life of the Cambrian; nevertheless, when we look around us and see the innumerable forms of life, both animal and vegetable, at present existing and mentally add to these the prolific forms of the various geological periods, most of which after playing a lengthened *rôle* in the ever ascending scale of animated beings have gradually died out, we feel ourselves forced to the conclusion, that if all these have been developed from a few primal germs, originating, no one knows how, within twenty-eight millions of years, they must have been supplemented, not once but many times, by more highly organized forms from disrupt ed planets, in Sir William Thomson's far famed meteorites.

It would perhaps be well to note here the vast difference which exists between the estimate of Mr. Wallace and that of the most celebrated geologists as quoted by him. Sir Charles Lyell basing his calculation upon the rate of modification of the species of mollusca, gives two hundred and forty millions of years as his estimate of time since the Cambrian period. Professor Haughton gives two hundred millions of years as the time denoted by the formation of stratified rocks, whilst Darwin, in the first edition of the "Origin of Species" estimated that the erosion of the Wealden Valley must have taken three hundred millions of years.

It would seem to us, therefore, that Mr. Wallace, in limiting the age of the stratified rocks in obedience to the requirements of the physicists, strikes a heavy blow at his own doctrines. The physicists are men, and as such are as liable to error as geologists, and there is no reason why their estimate "Of the possible sources of the heat of the sun and calculations of the period during which the earth can have been cooling to bring about the present rate of increase of temperature as we descend below the surface,"* may not be as erroneous as Mr. Wallace supposes the calculations of our best geologists to be, as to the rate of deposition of the sedimentary rocks. Darwin and Huxley both demand vast periods for the development of the numerous forms of life, and Mr. Wallace quotes the address of the latter to the Geological Society in 1870 as follows:—

"Professor Huxley adduced a number of special cases showing that, on the theory of development, almost all the higher forms of life must have existed during the Palæozoic period. Thus, from the fact that almost the whole of the tertiary period has been required to convert the ancestral Orohippus into the true horse, he believes that, in order to have time for the much greater change of the ancestral Ungulata into the two great odd-toed and even-toed divisions (of which change there is no trace even among the earliest eocene mammals), we should require a large portion, if not the whole, of the mesozoic or secondary period. Another case is furnished by the bats and whales, both of which strange modifications of the mammalian type occur perfectly developed in the Eocene formation. What countless ages

* "Island Life," p. 165. † Ibid., p. 228.

* "Island Life," p. 203.

back must we then go for the origin of these groups, the whales from some ancestral carnivorous animal, and the bats from the insectivora. And even then we have to seek for the common origin of carnivora, insectivora, ungulata, and marsupials at a far earlier period; so that on the lowest estimate we must place the origin of the mammalia very far back in Palæozoic times."

Again—

"If the very small differences which are observable between the crocodiles of the older secondary formations and those of the present day, furnish any sort of an approximation towards an estimate of the average rate of change among reptiles, it is almost appalling to reflect how far back in Palæozoic times we must go before we can hope to arrive at that common stock from which the crocodiles, lizards, Ornithoscelida, and Pleiosauria—which had attained so great a development in the Triassic epoch—must have been derived."

Again Mr. Wallace quotes Professor Ramsay, who, speaking of the "abundant, varied, and well-developed fauna of the Cambrian period," says:

"In this earliest known *varied* life we find no evidence of its having lived near the beginning of the zoological series. In a broad sense compared with what must have gone before, both biologically and physically, all the phenomena connected with this old period seem to my mind to be of quite a recent description, and the climates of seas and lands were of the very same kind as those the world enjoys at the present day."*

A curious comment on these words of Professor Ramsay is to be found in the recent investigations of the *Challenger*, for Sir Wyville Thomson in speaking of the curious abyssal fauna before noticed says:

"The recent abyssal fauna has a relation to the deep water fauna of the Oolite, the Chalk and Tertiary formations, so close that it is difficult to suppose it, in the main, other than the same fauna which has been subjected to a slow and continuous change under slightly varying circumstances, according to some law, of the nature of which we have not as yet the remotest knowledge. . . . There is every reason to believe that the existing physical conditions of this area date from a very remote period, and that the present fauna of the deep sea may be regarded as being directly descended from fauna which have successively occupied the same deep sea. In the meantime, changes involving lesser depths have been accompanied by the appearance and disappearance of the land and shallow water faunæ of the Jurassic, Cretaceous and Tertiary periods. That the present abyssal fauna is the result of progressive change there can be no room to doubt, but it would seem that in this case the progress has been extremely slow, and that it has been brought about almost in the absence of those causes—such as minor and local oscillations of the crust of the earth producing barriers and affecting climate—on which we are most inclined to depend for the modification of faunæ. The discovery of the abyssal fauna, accordingly, seems to have given us an opportunity of studying a fauna of extreme antiquity, which has arrived at its present condition by a slow process of evolution from which all causes of rapid change have been eliminated."*

Here it will be observed that the antiquity claimed for the present abyssal fauna must be extended to include that of the strictly allied fauna of the Oolite, Chalk and Tertiary periods, which, being so nearly alike, may have lived under similar conditions, that is, in *deep* sea of an equable temperature, generally only *just* above freezing-point, and unaffected by currents. But if so little change has taken place in deep-sea fauna since times so remote as are indicated by the Oolite and Chalk formations, how many ages back are we to look for the beginnings of this varied life, so slowly changing, which had yet attained so much perfection in Oolitic seas? It would seem impossible to place definite limits, however vast, to that which appears to demand greater expansion with each fresh discovery, and if geological time must be narrowed within the period demanded by physicists, the theory of evolution must either be discarded or greatly modified.† We need scarcely say that the latter alternative is scarcely likely to be accepted, seeing that every new fact in physical science, and every new discovery in Palæontology, only adds fresh proofs to the already abounding evidence in favour of the evolutionary hypothesis. Huxley, in the article upon "Evolution," in the new edition of the "Encyclopædia Britannica," writes:

"No exception is at this time known to the general law that every living thing is evolved from a particle of matter in which no trace of the distinctive characters of the adult form of that living thing is discernible. . . . How far 'Natural selection' suffices for the production of species remains to be seen. Few can doubt that if not the whole cause, it is a very important factor in that operation, and that it must play a great part in the sorting out of varieties into those which are transitory and those which are permanent. . . . The strongest and most conclusive arguments in favour of evolution are those which are based upon the facts of geographical, taken in conjunction with those of geological distribution. Both Mr.

* "Island Life," pp. 204, 205: quotations from Huxley's "Address to Geological Society," 1870, and Ramsay "On Comparative Value of Geological Ages as Items of Geological Time," Pro. Royal Soc., 1874.

* "Report of the Scientific Results of the Exploring Voyage of H.M.S. *Challenger* 1873–1876," vol. i. General Conclusions, VIII.

† It is true that Mr. Wallace considers that geographical and climatic changes have greatly hastened the naturally slow process of evolution, and that Sir Wyville Thomson believes the slow change in the abyssal fauna to be the result of unchanging conditions in deep seas; but this only pushes back to a yet more remote antiquity the origin of these slowly developed forms, and Huxley has shewn, as quoted above, how very slow has been the change in terrestrial faunæ, acted upon as they must have been by geographical and climatic changes.

Darwin and Mr. Wallace lay great stress on the close relation which obtains between the existing fauna of any region and that of the immediately antecedent geological epoch in the same region, and rightly, for it is in truth inconceivable that there should be no generic connection between the two. It is possible to put into words the proposition, that all the animals and plants of each geological epoch were annihilated, and that a new set of very similar forms were created for the next epoch, but it may be doubted if any one who ever tried to form a distinct mental image of this process of spontaneous generation on the grand scale, ever really succeeded in realizing it." *

Sir Wyville Thomson's researches on board the *Challenger* lead him to the same conclusion, he says: "I believe that the study of the abyssal fauna, revealing many delicate chains of structural affinity linking the fauna of the present with that of the past, brings into prominence a new mass of facts morphological, ontological, and Palæontological, in powerful support of the doctrine of Evolution." Here, however, he parts company with Messrs. Darwin, Huxley, and Wallace, for he adds:—

"On the other hand, it seems to me that in this as in all cases in which it has been possible to bring the question, however remotely, to the test of observation, the character of the abyssal fauna refuses to give the least support to the theory which refers the evolution of species to extreme variation, guided only by natural selection. Species are just as distinctly marked in the abyssal fauna as elsewhere, each species varying within its definite range as each species appears to have varied at all times past and present. If all the species living on the floor of ocean were, and had always been, in a state of instability, acted upon by external influences and perpetually passing by insensible gradations into other species, it seems certain that the general impressions drawn from a fauna, such as that of the abyssal region, must have been one of indefiniteness and transition. This is not the case. Transition forms, linking species so closely as to cause a doubt as to their limit, are rarely met with. There is usually no difficulty in telling what a thing is." †

Between the theory of evolution guided by some unknown law, as propounded by Sir Wyville Thomson, and evolution aided by natural and sexual selection accentuated by the struggle for existence and survival of the fittest, according to Darwin, we cannot pretend to decide, but it is evident that the former theory would require even longer periods for the production of the results observed, than the latter, and it is well known that the absence of intermediate or transition forms is one of the most serious objections to Mr. Darwin's theory. In the sixth edition of the "Origin of Species," the learned naturalist fully explains the difficulties which beset his theory through the absence of those rich fossiliferous deposits belonging to the assumed earliest periods prior to the Cambrian, and confesses that hitherto no satisfactory reason has been assigned for the deficiency. The geological record is admittedly imperfect, not only because many forms have undoubtedly died out without leaving a trace of their former existence, but also from the small space of the earth's surface as yet systematically and scientifically explored; every year adds to our list of fossils, and the American continent especially has yielded great results to recent investigations, so that each fresh field of exploration may be expected to yield prolific results, and to supply some at least of the many links at present missing from the chain of life. It must not however be forgotten that the greater part of the Tertiary, Secondary and Palæozoic geological strata are of marine, fluviatile, or lacustrine origin, and although they do undoubtedly show to a certain extent the nature of the fauna and flora of the land from which those deposits were derived, they cannot be expected to yield the full total of the terrestrial productions of the period which they represent. The question therefore naturally arises what has become of those ancient continents from which these enormous deposits have been derived? and this brings us back to the question of the "Permanence of Continents."

Mr. Wallace's views upon this subject have been noticed earlier, and the quotation from page 99 of "Island Life" will show how many modifications he is obliged to allow in the shape and dimensions of these early continents to account for the geographical distribution of animals and plants at present existing. He endeavours to prove that the Cretaceous, Oolitic and Silurian deposits could only have been formed "within 50 or 100 miles of then existing continents, or, if at a greater distance, in shallow inland seas receiving deposits from more sides than one, or in certain exceptional areas where deep ocean currents carry the *débris* of land to greater distances." * In this view he appears to be supported not only by the recent investigations of the *Challenger* but by the great authority of Mr. Darwin, who says:

"Looking to existing oceans which are thrice as extensive as the land, we see them studded with many islands; but hardly one truly oceanic island (with the exception of New Zealand, if this can be called a truly oceanic island) is as yet known to afford even a fragment of any Palæozoic or Secondary formation. Hence we may perhaps infer that during the Palæozoic and Secondary periods, neither continents nor continental islands existed where our oceans now extend; for had they existed, Palæozoic and Secondary formations would in all probability have been accumulated from sediment derived from their wear and tear; and these would have been at least partially upheaved by the oscillations of level which must have intervened during these enormously long periods. If then we may infer anything from these facts, we may infer that, where our oceans now ex-

* "Encyclopædia Britannica," 9th edition, Article "Evolution."

† "Report of the Scientific Results of the Exploring Voyage of H.M.S. *Challenger*."

* "Island Life," p. 84.

tend, oceans have extended from the remotest period of which we have any record; and on the other hand, that where continents now exist, large tracts of land have existed, subjected no doubt to great oscillations of level since the Cambrian period."*

But in spite of this great authority we cannot help reiterating the question "What has become of those great land areas which must have furnished the deposits of the sedimentary rocks?" Mr. Darwin to a certain extent answers this question, for he goes on to explain that which is omitted by Mr. Wallace, that prior to the Cambrian period continents may have existed where oceans now spread out.

That even the highest of existing mountains has at some time formed a portion of a deep sea bottom, is testified by the Silurian fossils recently found by Lieutenant Whymper on the top of some of the highest of the Andes, but it must not be forgotten that most of the high peaks of that great range of mountains, as well as those in other parts of the world, are of volcanic origin, like the islands now slowly sinking beneath the waves in the broad Pacific, and therefore the absence of Secondary and Tertiary strata on these islands would not appear to be absolutely conclusive evidence against their having ever formed part of a submerged continent. One thing is evident, if the present balance between land and water is to be maintained, an area of subsidence in one part of the world, must always mean an area of upheaval in some other part. Mr. Wallace's maps, however, appear to us to give everywhere great regions of subsidence, without, as far as we can judge, any corresponding areas of upheaval. The oceanic islands are everywhere sinking, the continental islands have been separated from the mainland by the depression of intervening land, but for all this no compensating upheaval appears to be allowed.†

Let us now see how, in the absence of that land connection which most naturalists have deemed essential, Mr. Wallace accounts for the curious anomalies of distribution apparent in island life. He first takes oceanic islands, that is, islands everywhere surrounded by a deep sea, and therefore apparently never united with a continent. Of these the Azores are first noticed, as having been the most thoroughly explored; the map annexed shows a shallow sea surrounding all the islands of the group so as to make it possible that they were all originally one; although Mr. Wallace does not consider that as probable. They are wholly volcanic, excepting one small island which possesses some miocene deposits, a fact which Mr. Wallace passes over lightly, as simply proving the group to have been of great antiquity, but does not look upon it as indicating a former union of the group or any considerable extension. The nearest island of the group is about 900 miles from Portugal, the nearest part of Europe, and 550 miles from Madeira. The Islands contain no indigenous mammals, but abound in birds, of which fifty-three species have been observed, thirty-one being either aquatic or waders. All these are common in Europe and North Africa, except three which inhabit Madeira and the Canaries; therefore Mr. Wallace concludes that they are all stragglers, since such are frequently found by vessels in strong gales of wind many hundreds of miles from shore. There are a few butterflies, moths, and Hymenoptera of European origin, whose presence is accounted for in like manner; 212 species of beetles are known, 175 being European, most of which are supposed to have been introduced by human agency. Twenty-three are not found in any other Atlantic island, thirty-six are not found in Europe, nineteen are natives of Madeira or the Canaries, three are American, and fourteen are peculiar to the Azores, but are allied to European species, although two are so distinct as to constitute new genera. The presence of these peculiar beetles and of many land shells, is accounted for by two suppositions, either that they are remnants of a former widespread group which have survived the glacial epoch and become extinct in their native country, or that they have been drifted across the ocean, either in the egg or in the transformation stage, in floating timber or stems of plants. Of the flora, 440 out of 480 flowering plants and ferns are found in Europe, Madeira, or the Canaries, whilst forty are peculiar to the Azores, but allied to European species. Some of these are supposed to have been conveyed by birds, many have winged seeds, and might have been borne by the winds and waves—trees and plants with heavy seeds being suggestively absent. The deduction drawn from the fauna and flora of the Azores is:

"That the peopling of remote islands is not due so much to ordinary or normal as to extraordinary causes. These islands lie in the course of the south-westerly return trades and also of the Gulf Stream, and we should therefore naturally expect that American birds, insects and plants would preponderate if they were con-

* "Origin of Species," 6th edition, p. 288.

† It seems somewhat difficult to follow Mr. Wallace's definition of the permanence of continents, for on page 221 of "Island Life" we read as follows: "In the first place, every continent, though permanent in a general sense, has been ever subject to innumerable physical and geographical modifications. . . . . But such changes as these must necessarily have led to repeated union and separations of the land masses of the globe, joining together continents which were before divided, and breaking up others into great islands or extensive archipelagoes. Such alterations of the means of transit would probably affect the organic world even more profoundly than the changes of area, of altitude, or of climate, since they afforded the means, at long intervals, of bringing the most diverse forms into competition, and of spreading all the great animal and vegetable types widely over the globe."

This would appear to meet all the requirements of naturalists; but it seems in direct variance with the assertions in other parts of the book as to that permanence of continental and oceanic areas, so much insisted upon.

veyed by the regular winds and currents, which are both such as to prevent European species from reaching them. But the violent storms to which the Azores are liable, blow from all points of the compass; and it is evidently to these combined with the greater proximity and more favourable situation of the coasts of Europe and North Africa, that the presence of a fauna and flora so decidedly European is to be traced." *

The next group of islands noticed is that of Bermuda, which consists of about a hundred small coral islands surrounded by reefs, beyond which is a very deep ocean. They are situated about 700 miles from North Carolina, and from cedar trees being found forty-eight feet below high-water mark, the whole area now occupied by shoals would seem at one time to have been included in the group. There is on these islands a layer of red earth or clay, which has been supposed to prove the elevation of the ocean bed to the surface, the red clay representing the red deposit discovered by the *Challenger* in mid-ocean, but Mr. Wallace concludes from the same red clay having been found "two feet thick under coral rock at a depth of forty-two feet below low-water mark, and resting on a bed of compact calcareous sandstone," which he says could never have been formed at the bottom of the ocean 700 miles from land, that this red clay is more probably due to some process of decomposition of the rock itself. The islands possess one peculiar lizard, 180 species of birds, only ten of which are permanent residents, and very few insects, all common North American or West Indian species. Of land shells one-fourth are peculiar, while almost all the other productions of the islands are identical with those of the adjacent continent and islands. Dr. Rein and Mr. Moseley found 250 wild flowering plants, less than half being indigenous. The origin of this flora is attributed to the Gulf Stream and to the annual cyclones, the migratory birds likewise often bringing seeds.

"If now, we consider," says Mr. Wallace, in summing up the evidence regarding the Azores and Bermuda, "the extreme remoteness and isolation of these islands, their small area, and comparatively recent origin, and that notwithstanding all these disadvantages they have acquired a very considerable and varied flora and fauna, we shall, I think, be convinced, that with a larger area and greater antiquity, mere separation from a continent by many hundred miles of sea, would not prevent a country from acquiring a very luxuriant and varied flora, and a fauna also rich and peculiar as regards all classes except terrestrial mammals, amphibia and some groups of reptiles." †

He then goes on to treat of the Galapagos Islands, remarkable for their gigantic tortoises, and also as possessing several lizards, and two species of snakes. These islands are volcanic, situated on the Equator, about 600 miles from the West Coast of South America, and are surrounded by a bank at a depth of 1,000 feet. The tortoises, Dr. Gunther believes, to be of American origin, as also are the lizards and the snakes; but their presence in the Galapagos seems not easily accounted for. Mr. Wallace thinks they might have been conveyed on uprooted trees. Of the birds of these islands, thirty-eight out of fifty-seven species are peculiar, although all are allied to birds inhabiting tropical America. This Mr. Wallace attributes to the fact that the Galapagos are not subject to storms, so that birds arriving by accidental migrations would have time to acquire peculiarities, not being disturbed by frequent additions from the continent. The insects and land-shells are also almost all peculiar. Of these, Mr. Wallace says: "The observation of Captain Collings, that drift-wood, bamboos, canes, and the nuts of a palm, are often washed on the south-eastern shores of the islands, furnishes an excellent clue to the manner in which many of the insects and land-shells may have reached the Galapagos." He also thinks some may have been conveyed by whirlwinds.

Of St. Helena, the next island described, we shall not say much, since its original fauna and flora have been so completely changed by human agency that very little now remains. It was formerly covered with forests of ebony, which were destroyed wastefully by Europeans, and by the goats introduced by them; but it still contains forty flowering plants and ten ferns peculiar to the island, mostly of South African affinities, which may, perhaps, be accounted for by a fact stated by Mr. Mellis, that large seeds which have floated from Madagascar or Mauritius round the Cape of Good Hope, have been thrown on the shores of St. Helena, and have then sometimes germinated. There are great peculiarities in the beetles of this island; judging from the flora, we should expect these, also, to have South African affinities; but although this is so to a certain extent, there is also a strong European element more difficult to account for; and, in order to do so, Mr. Wallace has to call to his aid great antiquity, the changes of climate produced by glacial epochs, warm polar climates, alterations of winds and currents, and probable changes in the height of mountains in equatorial Africa.

"During the changes of climate, which there is good reason to believe periodically occurred, there would be much migration from the temperate zones towards the Equator and the reverse. If, therefore, the nearest ally of any insular group now inhabits a particular country, we are not obliged to suppose that it reached the island from that country, since we know that most groups have ranged in past times over wider areas than they now inhabit." *

At all events, Mr. Wallace believes St. Helena to have always been an isolated oceanic island, surrounded by deep sea, and never to have been connected with any continent.

The last group of oceanic islands described is the Sandwich Islands, separated by enormous ocean depths from the nearest continent,

* "Island Life," chap. xii. p. 253.
† Ibid. p. 264.

* "Island Life," p. 290.

and therefore certainly never united to a continent, but with possible extension towards some of the other Pacific groups of islands at a remote period. These islands possess no mammalia, but have twenty-four species of aquatic and wading birds, four birds of prey, and of Passeres, sixteen species, all peculiar, their affinities being chiefly with Australia and the Pacific Islands, with

"Slight indications of very rare or very remote communication with America. The amount of speciality is, however, wonderful, far exceeding that of any other islands; the only approach to it being made by New Zealand and Madagascar, which have a much more varied bird fauna and a smaller proportionate number of peculiar genera. These facts undoubtedly indicate an immense antiquity for this group of islands or the vicinity of some very ancient land (now submerged) from which some portion of their peculiar fauna might be derived." *

The islands possess two lizards, one of which is said to be found also in Timor, Australia, and the Samoa Islands. The land-shells of the Sandwich Islands are also very remarkable. They are more numerous than in all the other Polynesian Islands, and three-fourths of the whole belong to peculiar genera, fourteen of which, constituting the sub-family Achatinellinæ, are entirely confined to these islands; thirteen genera are found in other Polynesian Islands, whilst three genera of Auriculidæ are not found in the Pacific; but one inhabits Australia, China, Bourbon, and Cuba, and the two others are found in the West Indian Islands. The insects have not as yet been fully enumerated; but all the chief tribes of Coleoptera seem to be represented. Most of them are peculiar, but have affinities in Polynesian, Australian, or Malayan forms; some are South American, and some show north temperate affinities. The flora of these islands is equally strange. Of 554 flowering plants, and 135 ferns, three-fifths are peculiar, their affinities being with Polynesian, Australian, New Zealand, and American forms; and some of those known to us as small plants, there grow to woody shrubs—shrubby geraniums fifteen feet high growing on forest trees.—The Compositæ are also highly peculiar, but have strong affinities with American forms.

These strange facts Mr. Wallace accounts for, as regards the Compositæ, by considering that group of plants to represent the most ancient portion of the flora conveyed to the Sandwich Islands

"At a very remote period, when the facilities for communication with America were greater than they are now. This may be indicated by the two deep submarine banks in the North Pacific, between the Sandwich Islands and San Francisco, which from an ocean floor nearly 3,000 fathoms deep, rise up to within a few hundred fathoms of the surface, and seem to indicate the subsidence of two islands, each about as large as Hawaii. The plants of north temperate affinity may be nearly as old, but these may have been derived from northern Asia by way of Japan, and the extensive line of shoals which run north-westward from the Sandwich Islands. Those which exhibit Polynesian or Australian affinities, consisting for the most part of less highly modified species usually of the same genera, may have had their origin at a later, though still somewhat remote period, when large islands, indicated by the extensive shoals to the south and south-west, offered facilities for the transmission of plants from the tropical portions of the Pacific." *

Mr. Wallace considers this singular flora to be consistent with what is known of the fauna of the islands, which also shows some indication of an ancient approach to America, and believes that the organic forms in oceanic islands show long isolation, whilst preserving for us in archaic forms some record of the primæval immigration which clothed them with verdure. They are all less rich in animal and vegetable life than islands which have at any time formed parts of continents, and all agree in the absence of mammalia, are all volcanic or coralline, built upon degraded and submerged volcanic islands, and none of them possess a single type preserved from Mesozoic times.

Let us now see what the continental islands have to tell us respecting the origin of their animal and vegetable forms.

We shall pass over Great Britain and Ireland for want of space, and because their geological, zoological, and botanical records are tolerably well known. Suffice it to say, that whilst zoologically and botanically they are almost identical with the European continent, having been comparatively recently separated from it, yet this separation has caused the evolution, or preservation, of three peculiar species of birds, fifteen species of fresh-water fishes, sixty-nine species of Lepidoptera, seventy-two species of Coleoptera, several fresh-water shells, and many flowering plants and mosses, whilst they possess fewer mammals even than Scandinavia, which has sixty species, the number for Great Britain being forty, and for Ireland—probably earlier separated—only twenty-two. Of reptiles, Belgium has twenty-two species, Britain thirteen, and Ireland only four. This poverty of reptiles Mr. Wallace attributes "to their lower vital activity and smaller powers of dispersal," which seems, as previously remarked, to be somewhat at variance with the records given of the oceanic islands, which almost all possess one or more species of reptile, although wholly deficient in mammalia.

In addition to the British Isles, the Malay Islands, Borneo and Java, the Philippine Islands, Japan and Formosa, are given as types of *Recent* Continental Islands. These all, whilst strongly resembling the Asiatic continent, from which, and from each other, they have been separated at different periods, yet possess a great many peculiar species, Java being especially remarkable, because

* "Island Life," p. 308.

* "Island Life," p. 309.

although only separated from Sumatra by the narrow Straits of Sunda, it shows greater differences than Borneo, which is much more remote. Java has also resemblances to the Siamese Peninsula, and to the Himalayas, which Borneo and Sumatra do not possess; whilst it is also remarkable for the absence of no less than thirteen genera of mammalia, which inhabit the two adjoining islands and the Malayan peninsula; in some cases the same species being found in all three of the Malay countries, but represented in Java by an *allied* species. These peculiarities Mr. Wallace accounts for by a series of geographical changes, aided by changes of climate, "driving a portion of the Himalayan fauna southward, leaving a few species in Java, from which they could not return, owing to its subsequent isolation by subsidence."*

The geographical changes Mr. Wallace supposes to have commenced in Miocene times, in which the whole of the shallow seas uniting Sumatra, Java, Borneo, and the Philippines with Asia, became dry land by elevation, and here the Malayan fauna was developed. After a long period of stability, the Philippines were first separated; then, considerably later, Java; a little later, Sumatra and Borneo; and, finally, the islands south of Singapore to Banca and Biliton.

Japan may be aptly compared to Great Britain, not only in climate, but geologically in its recent connection with the adjacent continent; and singularly enough, although separated by the breadth of two continents from the British Islands, it possesses forty identical species of birds, and many more bearing a strong resemblance to ours; indeed, Mr. Wallace begins his work by pointing out that the traveller from Britain to Japan will, after his long voyage, find less difference in the productions of these remote countries than between Australia and New Zealand, only thirteen hundred miles apart. Nevertheless, Japan possesses many peculiar forms, some of which are allied to America, and some to the Himalayas and the Malay Islands; but owing to the easy passage still existing from the northern extremity of Japan through Saghalien to the mainland of Asia, a large number of temperate forms of insects and birds are still able to enter the country, and thus diminish the proportionate number of peculiar species. There are some great peculiarities in the mammalia of Japan and Formosa, which have American as well as European, and Asiatic affinities. But we have not space to recapitulate them, as we must pass on to the yet more interesting class of islands, termed by Mr. Wallace the *Ancient* Continental, including the Madagascar group, Celebes, and New Zealand.

Madagascar lies so close to Africa that one would naturally expect it to resemble that continent in its organic productions, as nearly as Great Britain resembles Europe, and Japan Asia. But what do we find? In an exceedingly rich and beautiful fauna and flora there is a most singular combination of types from all parts of the world.

Of sixty-six species of mammals, not one of the great African groups is found in Madagascar; but there are Lemurs, which are found from "West Africa to India, Ceylon, and the Malay Archipelago." Insectivora, among which is a peculiar family (Centetidæ), which exists nowhere else on the globe, except in the two largest West Indian Islands, Cuba and Hayti; Carnivora, including civets of peculiar genera, but allied to African groups, and a peculiar cat-like animal, Cryptoprocta, having no allies in any part of the globe; Rodents, among which are four rats and mice of peculiar genera, and a small subfossil hippopotamus. Of reptiles, the Colubrine snakes are represented by two American genera, whilst another genus is found in America and China; the other genera are all peculiar, whilst two abundant African families are absent. The lizards are all peculiar, some (as the Iguanidæ) belonging to families exclusively American; "while a genus of geckoes, inhabiting America and Australia, also occur in Madagascar." The birds are equally peculiar, and are more nearly allied to those of India and the Malay Islands than to Africa, several well-known African families being wholly absent. The islands round Madagascar share in its peculiarities. The giant tortoises of the Mascarene Islands are well known, from specimens in the Zoological Gardens and the British Museum, whilst the curious recently-extinct birds which inhabited Mauritius, Bourbon, and Rodriguez, the Dodo, and its allies, are found nowhere else, but are supposed to be a degraded pigeon. The flora of Madagascar and the neighbouring islands is as anomalous as the fauna, presenting many peculiar forms, some of African, but more of Asiatic affinities; a few found elsewhere, only in South America, Australia, and Polynesia; "whilst more than half the total number (536 of 1,058) are found *only* in some of the islands of the Madagascar group." Mr. Wallace thus explains the curious and apparently irreconcilable anomalies here briefly recapitulated.

"In Madagascar we have a continental island of the first rank and undoubtedly of immense antiquity; we have detached fragments of this island in the Comoros and Aldabra; in the Seychelles we have the fragments of another very ancient island, which may perhaps never have been continental; in Mauritius, Bourbon, and Rodriguez, we have three undoubtedly oceanic islands; while in the extensive banks and coral reefs of Cargados, Saya de Malha, the Chagos and the Maldive Islands, we have indications of the submergence of many large islands which may have aided in the transmission of organisms from the Indian Peninsula. But between and around all these islands, we have depths of two thousand five hundred fathoms and upwards, which renders it very improbable that there has ever been here a continuous land surface, at all events during the Tertiary or Secondary periods of Geology."*

He then goes on to argue that in no one

* "Island Life," chap. xvii.

* "Island Life," p. 417.

case do we find animals necessitating an actual land connection with India. That the distribution of the lemurs supposed to require this connection,

"Can be far more naturally explained by a general dispersion of the group from Europe, where we know it existed in Eocene times; and such an explanation applies equally to the affinity of the Insectivora of Madagascar and Cuba; the snakes of Madagascar and America, and the lizards of Mauritius and Australia. To suppose in all these cases and in many others, a direct land-connection is really absurd, because we have the evidence afforded by geology of wide differences of distribution directly we pass beyond the most recent deposits; and when we go back to Mesozoic, and still more to Palæozoic times, the majority of the groups of animals and plants appear to have had a world-wide range. A large number of our European Miocene genera of vertebrates were also Indian or African or even American; the South American Tertiary fauna contained many European types; while many Mesozoic reptiles and mollusca ranged from Europe and North America to Australia and New Zealand."*

Now granting Mr. Wallace's favourite theory of the permanence of continents and oceans, it would seem to us as impossible to account for the world-wide distribution of these mammalian forms in Palæozoic and Mesozoic as in Tertiary times, and to suppose that they could cross the ocean from Europe to South America, Australia, and Madagascar, with only intervening islands, would appear quite as absurd as the existence of that hypothetical Lemuria so strenuously denied by Mr. Wallace, but still firmly believed in by many geologists and naturalists, and which would seem to be indicated not only by the fauna of Madagascar and adjacent islands, but also by the submerged islands indicated by Mr. Wallace himself:—

"Africa," says Mr. Wallace, "was cut off from Europe and Asia by an arm of the sea in early Tertiary times. . . . . The large mammalia now found in Africa (but which are absent from Madagascar) inhabited Europe and Asia, and many of them also North America in the Miocene period. At a still earlier epoch, Africa may have received its lower types of mammals, lemurs, insectivora and small carnivora, together with its ancestral struthious birds, and its reptiles and insects of American or Australian affinity."

But *how* and *by what route* he fails to say, seeing that Africa at that time is itself supposed to have been an island continent like Australia, and unable to obtain the higher mammals then inhabiting Europe and Asia.

"At that period," he adds, "Africa was joined to Madagascar. Before the later continental period of Africa, Madagascar had become an island; and thus when the large mammalia from the northern continent overran Africa, they were prevented from reaching Madagascar, which thenceforth was enabled to develop its singular forms of low type mammalia, its gigantic ostrich-like Æpyornis, its isolated birds, its remarkable insects, and its rich and peculiar flora."*

Reluctantly passing over Celebes with its very peculiar fauna, which Mr. Wallace supposes to have been derived from Asia by means of migration across narrow straits—Celebes never having been united to the continent—we turn to New Zealand, classed among continental, rather than oceanic islands, because the 1,000 fathom line indicates a former extension towards Australia, to which it would appear to have been once united by a narrow isthmus, which stretches across to the Great Barrier Reef towards the north. The most remarkable thing therefore about the fauna and flora of New Zealand is, that they show so *few* Australian forms. The great Australian marsupials are wholly wanting in New Zealand, which contains only two doubtfully indigenous mammals, a rat and an otter-like animal, and two species of bats, no snakes, and only one frog, but has an extensive group of birds incapable of flight, which has recently become extinct; these birds are classed with the ostrich tribe, though differing in many respects from all known birds; they have, however, resemblances with the apteryx still living in New Zealand, with the emu of Australia, and the cassowaries of New Guinea.

The flora of New Zealand has always been regarded as peculiarly puzzling. Of 935 species of flowering plants, 677 are endemic; of 258 species not peculiar to the islands, 222 are Australian, but many of these are also Antarctic, South American, or European. On the other hand seven great genera of Australian plants, each containing more than 100 species, are entirely absent from New Zealand, whilst many other Australian genera are only partially represented, and only about one-eighth of those occurring in both countries belong exclusively to that region, and of these several are better represented in New Zealand than in Australia. Among those conspicuously absent are the Eucalyptus and Acacia, which form such noticeable features in Australian landscapes. Of these New Zealand peculiarities Sir Joseph Hooker speaks thus:—

"New Zealand does contain certain Australian species and types, but these are not the most common or most likely to have arrived by transoceanic migration. The arboreous vegetation of Australia mainly consists of gum trees and leguminous plants, which cover three-fourths of the wooded parts of that continent, but not one is found in New Zealand; yet the seeds of the gum trees are very minute, are shed in inconceivable quantities, retain their vitality long, and both gum trees and acacias when introduced by man into New Zealand, become naturalized at once, and actually displace the indigenous vegetation of the island."†

Let us see how Mr. Wallace accounts for the singular facts we have briefly recorded. He first supposes a union with North Australia

* "Island Life," p. 418.

* "Island Life,' p. 419.

† "A Lecture on Insular Floras," by J. D. Hooker, D.C.L., LL.D., F.R.S., F.L.S., etc.

and New Guinea at a very remote epoch; that at that time that portion of Australia united to New Zealand was separated from the rest of Australia by a sea, and possessed no mammalia, since which period it has been reunited to Australia, and so completely severed from New Zealand as to prevent any migration even of winged birds; he further thinks that there may have been an extension northwards even as far as the Tonga and Fiji Islands, and southward towards the Antarctic continent; but he imagines the theory of the breaking up of this extensive land into islands, in which the various species of moa and kiwi were developed, their union at a later period, and the final submergence of all but the existing islands, as advocated by Captain Hutton, to be hypothetical, although it would account for some anomalies of bird and plant distribution.

In following "Island Life" thus far, as closely as space will permit, we shall at least have given our readers some idea of the difficult and intricate nature of the problems dealt with by Mr. Wallace and by others who have sought to give some reason for the singular facts in the distribution of animal and plant life, which seem to set all theories at defiance. Moreover, it must be remembered that the difficulties which beset all explanations hitherto offered, are by no means lessened, when we take the records of geology to our aid: we have already spoken of the proofs of the ancestors of the horses and camels of the eastern hemisphere having inhabited America in early geologic times, and of kangaroos and other marsupials having been found in our islands, but another enigma of the same kind is afforded by the distribution of struthious birds past and present. "The New Zealand Struthiones," says Mr. Wallace, "very nearly equal in number those of all the rest of the world, and nowhere do more than three species occur in any one continent or island, while no more than two ever occur in the same district;" * but in New Zealand ten out of the eleven known species of Dinornis have been found in a single swamp in the south island, where also three species of Apteryx are now found. At present

"There appear to be two closely allied species of Ostriches inhabiting Africa and south-western Asia respectively, South America has three species of Rhea each in a separate district, Australia has an eastern and a western variety of Emu, and a Cassowary in the north, while eight other species of Cassowaries are known from the islands north of Australia."†

The geological record is as follows:—

"Remains of extinct rheas have been found in Central Brazil, and those of ostriches in North India; while remains, believed to be of struthious birds, are found in the Eocene deposits of England; and the Cretaceous rocks of North America have yielded the extraordinary toothed bird Hesperornis which Professor O. Marsh declares to have been 'A carnivorous swimming ostrich.'"‡

* "Island Life," p. 449.
† *Ibid.* ‡ *Ibid.* p. 451.

Since Mr. Wallace will not allow a land connection to account for these facts, he resorts to the theory that these struthious birds had not a common origin, but, like the Dodo, are degenerated descendants of flying birds, which could also swim, as the Rhea and Emu can now. It must, however, be allowed that Mr. Wallace's utterances on this point are somewhat obscure, for he says:—

"We have found in almost every case that groups now scattered over two or more continents, formerly lived in intervening areas of existing land. Thus the marsupials of South America and Australia are connected by forms which lived in North America and Europe. The camels of Asia, and the llamas of the Andes, had many extinct common ancestors in North America; the lemurs of Africa and Asia had their ancestors in Europe, as did the trogons of South America, Africa, and tropical Asia." *

Wherever we find instances of peculiar distribution like those given above, or discontinuous distribution of living species, Mr. Wallace supposes it to represent a group in process of extinction, which had formerly a much wider range, but how under his theory of the permanence of continents, this wider range could have been attained, he does not explain. It is tolerably certain that such creatures as lemurs, kangaroos, camels, &c., would find even one hundred miles of sea an insuperable barrier; how, therefore, some could have ranged from America to Europe, and others from Europe to Australia, without any assistance excepting a few intervening islands, whilst they seem to have altogether scorned New Zealand, which one would have supposed equally attractive and easy of approach, is certainly a problem which "Island Life" leaves unsolved.† The peopling of the world under the existing distribution of land and water, according to the ancient Biblical story, would require not one but many hundreds of Noah's arks, or many hundreds of new creations, but even accepting the doctrine of evolution, we cannot imagine creatures of the same species springing up spontaneously in different parts of the world, nor mammals crossing miles of ocean unaided. We believe, therefore, that Mr. Wallace's theory will have to be considerably modified before it meets with general acceptance. Professor Huxley speaking, not of Mr. Wallace's book, but of the similar theory enunciated by Sir Wyville Thomson, says:—

"Surely there is evidence enough and to spare, that the cretaceous sea, inhabited by various forms, some of whose descendants Sir W. Thomson, as I believe justly, recognizes in

* "Island Life," p. 451.

† Mr. Starkie Gardiner says, "A much more southerly land connection between England and America seems required to explain the presence of tropical American plants, such as palms, in our Eocene, because their absence in beds of corresponding age in the United States and Greenland, implies that they did not pass along the northern route traced out for them."

the present deep-sea fauna, once extended from Britain, over the greater part of central and southern Europe, North Africa, and western Asia to the Himalayas. In what possible sense can the change of level which has made dry land of, and sometimes mountain masses of, nine-tenths of this vast area, be said to be 'In direct relation to the present existing coast lines.'"

It is, however, this cretaceous deposit which is one of Mr. Wallace's points of attack, for he endeavours to prove by many arguments that chalk instead of being a deep-sea deposit is always formed in shallow water near to the shore, an opinion ably controverted by Mr. Starkie Gardiner in the *Popular Science Review*. It must not, however, be supposed that Mr. Wallace in formulating his theory of the permanence of continents, ignores or repudiates geographical changes; on the contrary, he admits so many oscillations of the earth's crust, that most readers will be considerably mystified as to the meaning to be attached to the word *permanent*, whilst a glance at his maps showing the supposed land extensions, will lead many to infer that in indignantly denying the possibility of the existence of a Lemuria, the quarrel is more with the name than the reality, for the southward extension of the Indian peninsula and the islands connecting it with Madagascar, requires but little to perfect the chain, and if we place Lemuria more to the east, it will be seen that the great extent of shallow sea enclosed within the 1,000 fathom line, embracing the great islands of Borneo, Celebes, New Guinea, and New Zealand, and uniting them to Australia, has an extremely continental appearance, whilst the great islands allowed to have extended across the Atlantic differ but little from the fabled Atlantis of the ancients.

Mr. Wallace justly lays great stress upon change of climate as affecting the distribution of animal and vegetable life, and naturally brings forward the glacial period or periods, as having greatly modified the then existing fauna and flora; he also devotes many pages to the discussion of the causes which produced these glacial epochs, and the yet more enigmatical mild arctic climates, the existence of which has been demonstrated by recent discoveries. In this matter also Mr. Wallace has a theory of his own. Whilst agreeing in the main with Croll as to the effect of high periods of excentricity of the earth's orbit in producing glacial epochs, he does not allow that every period of high excentricity must necessarily produce a glacial epoch, because he believes that geographical changes, causing alterations in the ocean currents, would be sufficient to neutralize the effect of greater solar distance, and to produce even those mild arctic climates proved to have formerly prevailed by recent discoveries of coal, corals, and fossil plants of sub-tropical type, within the arctic circle. This theory has been warmly discussed in *Nature*, and we have not space to treat of it at present, but would only remark that a point incidentally alluded to by Mr. Wallace—that of the necessity for a greater amount of *light* as well as of *heat* for the development of these sub-tropical forms, than can be had within the polar circle under present circumstances—requires much greater attention than has hitherto been given to it, for within it we believe lies the key to that problem which has long exercised the minds of geologists and physicists, but which we still regard as unsolved—that of the alternations of glacial and temperate or sub-tropical climates in the northern hemisphere.

The effect of ocean currents is doubtless very great, and it is difficult to estimate what would be the amount of heat conveyed by several tropical streams having free access to the North Pole: that the Gulf Stream sensibly affects the climate of Great Britain is universally acknowledged, although many people think the effects exaggerated. Sir Charles Lyell believed that the flooding of the Sahara would be a great factor in the production of cold in the northern hemisphere, whilst Mr. Wallace would apparently regard it as a heat producer. The conflict of opinions between geologists on points such as these is great, and until some means can be found of ascertaining the exact distribution of land and water during the different geologic periods, and the contemporaneity of those periods, such conflicts of opinion are likely to continue. The theory of Mr. Wallace and Sir Wyville Thomson as to the permanence of continents, if it could be maintained, would certainly help towards a solution of some disputed points, but the stability claimed is so very unstable that it would at present seem to render the subject more intricate than before. The absence of mammals from the oceanic islands is a point in favour of Mr. Wallace's views, but we cannot regard his theories as to the various peculiarities observable in the fauna and flora of remote islands, whether oceanic or continental, as satisfactory. Every reader of "Island Life" will be struck by the purely hypothetical air pervading it. As a natural consequence of the rejection of the older theory of geologists, of the necessity of a land connection in the distribution of animals and plants, everything becomes the result of accident. Birds incapable of lengthened flight are driven hundreds of miles by storms; seeds and insects are caught up by whirlwinds and deposited on oceanic islands, or they are conveyed on driftwood, or in the crops or claws of birds, seeds and even plants are swept away hundreds of miles by ocean currents, and germinate after long immersion in sea water, &c. &c. That such things do sometimes happen has been proved by Mr. Darwin, but whether these accidents are sufficient in number and in frequency to account for the stocking of remote oceanic islands with plants and animals must remain doubtful, notwithstanding the strong points urged in favour of trans-oceanic migration by Messrs. Darwin and Wallace. Sir Joseph Hooker has placed before us the difficulties which beset the trans-oceanic as well as the continental theory, in his interesting Paper on "Insular Floras," where he points out that winds and

ocean currents would bring American and not European plants to the Azores, giving also innumerable instances where the animals and plants of an island are derived not from the nearest but from the most distant continent, as we have before pointed out in the cases of Madagascar and New Zealand. Nevertheless he, in common with almost all men of science, looks upon Darwin's theory as that best calculated to account for the various anomalies observable both in animal and plant distribution, and as giving some reason for the specialized varieties which are sure to be found on islands long isolated. When, therefore, we find Darwin, Wallace, and Sir Wyville Thomson, agreed as to the general permanence of the present continental areas, and the trans-oceanic migration of animals and plants, we may be sure that in venturing to oppose their ideas, either scientifically or dogmatically, we shall feel ourselves face to face with very powerful adversaries, and shall have need to buckle on our most efficient armour; for they are never exponents of crude ideas, but have well weighed every theory, and viewed it from every possible point, before presenting it to public criticism. Therefore, in venturing to differ somewhat from Mr. Wallace's views in some few points, we do so with much diffidence, feeling that these differences are probably due to want of proper apprehension on our part, rather than to error in the author. In any case we feel sure that a perusal of "Island Life" will afford pleasure both to the scientific and to the general reader, and will yield much food for earnest thought, although the theories it enunciates may perhaps remain unproved and unprovable for years, until fresh geological, Palæontological and astronomical discoveries shall have removed them from the Limbo of doubt, either into the Hades of darkness, or the region of truth and light.
