THURSDAY, FEBRUARY 17, 1881

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. (London: Macmillan and Co., 1880.)

I.

MR. WALLACE is to be congratulated on his success in that most difficult part of book-writing—the choice of a good descriptive, yet short and euphonious, title. "Island Life!" What do not the words suggest! How many old associations do they not recall! A vacant and unsuspicious reader may indeed be lured by them to open what he may expect will prove a good novel, perhaps a story of the "Robinson-Crusoe" type. His hopes will be quenched by the first chapter; but if he possesses any capacity for an interest in the flowers, insects, birds, and beasts of his home, it will almost certainly be quickened by a perusal of that chapter. Like a skilful composer Mr. Wallace strikes at once with a firm touch the key-note of his volume. In a few pages he puts before us the problem he seeks to solve, and does this in so graphic and masterly a way that most readers will not only comprehend what he aims at, but will be persuaded into the belief that as they are familiar with some parts of the subject they have a personal interest in seeing what the author can make of it.

Hardly any problem in modern science is at once so complex and so fascinating as the geographical distribution of plants and animals. Strange to say, this complexity and fascination have steadily increased with the growth of knowledge. A generation ago the grouping of floras and faunas found a ready explanation in differences of climate and special creations. But no such easy solution of the difficulties now avails. Ever since the classic essay of Edward Forbes on the history of the British flora there has been a growing conviction that the present arrangement of the life of the globe is the outcome of previous geological and biological changes. The doctrine of evolution has given to this conviction the strength of demonstrated truth. But while the theoretical aspect of the question may be clear enough, we are beset on all sides by what seem utterly insuperable obstacles when we try to work out the application of this theory to the history of any given flora or fauna. This is true even in those areas of Europe and North America where the living plants and animals are most fully known, and where some approach to a complete unravelling of the geological record has been made. But over most of the rest of the globe our knowledge of botanical and zoological distribution, and still more of geological history, is of the scantiest and most fragmentary kind. A few broad facts in the history of the mammalian life of the northern hemisphere are well established. The pedigree of some modern forms, such as the horse, can be traced back into early Tertiary times; the former wide spread of other forms, the lion for instance, and their gradual restriction in area, have been satisfactorily made out. But the kind of evidence available in these cases fails us in dealing with others. It seems as if all that we may hope to achieve is to establish by a few examples, capable of clear proof, the general laws by which variation in form and in geographical distribution appears to have been effected among the animal and vegetable populations of the globe.

By no living naturalist could these problems be more fittingly and exhaustively discussed than by the author of "The Malay Archipelago." Years of research in the East, followed by years of research and reflection at home, have enabled him to explore every highway and a vast number of byways in the wide realm of inquiry in which he has been so active and untiring a worker. Thoroughly conversant with all that has been done by others, he brings to his task a wealth of information and a breadth of view that stamp his works with the authority of a master.

The present volume may be regarded as an expansion of a part of the author's "Geographical Distribution of Animals." Further study of the problem of distribution has enabled him to treat it with greater fulness. He has devoted especial attention to geological operations that have affected the successive races of plants and animals, and has connected these operations with biological changes more closely and clearly than has hitherto been done. Of his new volume the first half is mainly occupied with a discussion of this subject. He there seeks to establish a number of fundamental propositions or laws, the confirmation of which leads in his opinion to a simpler and fuller solution of the problem than has before been possible. Two of these doctrines deserve the careful consideration of geologists and naturalists. They are (1) the permanence of continental and oceanic areas; and (2) the frequency of changes of climate during geological time and the combined influence of cosmical and geographical causes in the production of these changes.

The abundance of marine organisms in the rock-masses which constitute the bulk of the continents naturally led to a belief in the mutability of the land. Not once only but many times in succession the sites of some of our loftiest mountains were under the sea. And if it was discovered that the position of the land had been so variable, and that the sea-floor had been so continually upraised, the inference was easily drawn that land and sea must have been continually changing places. Tacitly or explicitly it was assumed that just as there appeared to be no area, even in the heart of the continents, which had not been submerged beneath the waves, so there was probably no tract even of mid-ocean where a continent might not have bloomed. It is probably a safe assertion to say that this is still the belief of most geologists. It finds formal expression in their most authoritative text-books, and can be traced everywhere in its influence upon the discussion of questions of geological history. From geological treatises it has passed out into the current literature of the time, as one of the accepted conclusions of science. Our Poet Laureate, who has embodied in musical language not a little of the scientific speculation of his day, has given terse expression to this universal belief in the often-quoted lines:—

> "There rolls the deep where grew the tree.
> O earth, what changes hast thou seen!
> There, where the long street roars, hath been
> The stillness of the central sea."

Inevitable as was this belief in the early days of geology, and firmly as it still maintains its hold, it is unquestionably based upon a partial view and erroneous interpretation of the facts. This has for some years been recognised by a few writers, and will before long be generally acknowledged. Instead of shifting their places on the earth's surface, continents, so far as the evidence of their history can be gleaned, have been wonderfully persistent.

This conclusion is reached by many different paths of inquiry. Of these it may suffice to notice here only two. (1) The rocks of which the greater part of the dry land consists, are upraised marine sediments. But their materials were derived from the waste of neighbouring dry land. They everywhere contain indications of the proximity of that land, and even reveal terrestrial surfaces, such as rippled-marked and rain-pitted shores, in the very midst of marine formations. Nowhere do they present indications of really deep water. (2) An examination of the floor of the present ocean proves that the sediment now removed from the surface of the continent is deposited in the shallower waters within 150 or 200 miles from land. Beyond this limit terrestrial sediment ceases to be transported and deposited, its place being taken by organic accumulations and by peculiar red and grey "clays" in which the inorganic material is mainly of volcanic origin, and must gather on the bottom with almost inconceivable slowness. This grouping of the detritus, derived from the degradation of the land, is evidently the only one possible, and it has now been abundantly demonstrated by recent deep-sea researches. We may be sure also that it must always have obtained in every geological period. The coarser and more lenticular sheets of sediment have accumulated nearest to the sources of supply, that is to the shores of the land; while the finer and more wide-spread silts have been spread over the farther and deeper tracts of that still comparatively narrow belt of sea to which sedimentation has always been mainly confined. To hasty readers it will seem an obvious and ridiculous paradox to maintain that the continents have been permanent throughout geological time, and yet to admit that probably no part of their surface has not been many times submerged beneath the ocean. Further reflection, however, and better acquaintance with the facts will convince every candid inquirer that the paradox is only in appearance. The continental ridges have been the great lines of terrestrial movement from the dawn of geological history. They have continually been undergoing disturbance; one portion has been equably upraised, another has been convulsed and corrugated, a third has been depressed. Every part of their surface has been subject to these changes. Moreover every portion of the crust which has risen above the sea-level has been exposed to the unremitting attacks of the subaërial agents of destruction. Again and again the solid bulk of the continents has been reduced to mere detritus and has been spread over the sea-bottom. And yet the continental ridges have never ceased to exist. Their disappearance would necessarily have been followed by the cessation of sedimentary accumulation. The character of their component rocks however teaches that, whether by the operation of underground movements or by the action of superficial causes, the land has been continually wandering, as it were, to and fro across the continental areas, disappearing beneath the sea in one region, reappearing from the sea in another. In one sense of course it may be said that land and sea have been continually changing places. But the submerged land has not become truly a part of the oceanic realm. The waters covering it have been mere prolongations of the upper layers of the ocean, like the Mediterranean, Black, and Caspian Seas of the present day. An elevation or depression of a few hundred feet, sufficed to turn wide tracts into land or into water. But such oscillations made no real change in the essential position of the grand aboriginal oceanic basins and continental ridges.

Mr. Wallace has thoroughly grasped the truth and significance of these averments, and has not been slow to perceive their fundamental importance in the history of terrestrial floras and faunas. He finds that they furnish new and unexpected assistance to the student of biological evolution, and indeed form a necessary part of the doctrine. "It is impossible," he says, "to exaggerate or even adequately to conceive the effect of these endless [terrestrial] mutations on the animal world. Slowly but surely the whole population of living things must have been driven backward and forward from east to west or from north to south, from one side of a continent or a hemisphere to the other. Owing to the remarkable continuity of all the land masses, animals and plants must have often been compelled to migrate into other continents, where in the struggle for existence under new conditions many would succumb; while such as were able to survive would constitute those widespread groups whose distribution often puzzles us. Owing to the repeated isolation of portions of continents for long periods, special forms of life would have time to be developed, which when again brought into competition with the fauna from which they had been separated, would cause fresh struggles of ever-increasing complexity, and thus lead to the development and preservation of every weapon, every habit, and every instinct which could in any way conduce to the safety and preservation of the several species."

Besides interchanges of sea and land Mr. Wallace lays great stress upon former vicissitudes of climate as agents in the modification of plant and animal life. He has discussed this subject with great detail and offers an original explanation of the causes of secular changes of climate. Adopting generally Dr. Croll's views as to the relation between the Glacial period and the excentricity of the earth's orbit, he introduces into them certain modifications and limitations. If, he argues, the effects of a high excentricity have always been shown in great Polar refrigeration and a general lowering of the temperature in the hemisphere whose winter occurred in *aphelion*, there ought to be geological evidence of the change. He confesses however that although indications of local ice-action have been noticed in different geological formations, even as far back as old Palæozoic deposits, there is certainly no trace of such general glaciations as the theory would lead us to expect. Not only so, but the testimony of organic remains is everywhere and unmistakably against the theory. He concludes, therefore, that while the astronomical influences must unquestion-

ably be a *vera causa* in the production of terrestrial climate, and must always *tend* to produce alternate mild and severe conditions, there must be some counteracting cause whereby these influences are weakened or neutralised. This modifying effect he assigns to changes in the distribution of land and sea, especially in high latitudes. He contends that without lofty land there can be no permanent snow and ice. Consequently by the due elevation of Arctic land an area would be provided on which, when winter occurred in *aphelion* during a period of high excentricity, there would be so copious an accumulation of snow and ice, that even during *perihelion* the wintry conditions would continue, and perhaps even in an intensified form. Subsidence of this land, however, would admit the warm oceanic currents from lower latitudes, and so great would be the amount of heat thereby transferred that even winter occurring when the North Pole was turned from the sun and the earth's orbit was at a maximum of excentricity would be insufficient to cover the Polar regions with an ice-cap. The alternate phases of precession, which tend to bring warmer and colder conditions of climate every 10,500 years, would introduce a complete climatal change only where the land was partially snow-clad. The general conclusion is thus reached that, the climates of the globe being mainly dependent on geographical conditions, their mutations in former periods have been chiefly brought about by changes in physical geography. Mr. Wallace supports these views by much ingenious reasoning. He argues that during by far the greater part of geological time the distribution of land has been such that warm oceanic currents have been able to pass freely to the North Pole, giving a mild climate to the whole northern hemisphere. He would thus account for the palæontological evidence of long-continued glacial conditions within the Arctic circle from Palæozoic to late Tertiary times. It was only in very recent times, he thinks, that the great northern continents became so completely consolidated as to shut out the tropical currents and to render possible the wide-spread and intense glaciation which was actually brought about by the high excentricity that occurred about 200,000 years ago. According to this view geographical revolutions "have been the chief, if not the exclusive, causes of the long-continued mild climates of the Arctic regions, while the concurrence of astronomical influences has been essential to the production of glacial epochs in the temperate zones, as well as of local glaciations in low latitudes."

In a remarkable chapter, remarkable as the deliberate judgment of an accomplished naturalist, the author decides that the vast periods of time which used to be demanded for the changes of geological history are not required even for the evolution of the floras and faunas of the earth. He admits, with some geologists who have advanced the same view from physical data, that geological changes probably occurred more vigorously and rapidly in former times than they do at present, and as these changes have always been accompanied by relative alterations in the forms of the organic world, he believes that organic evolution has taken place far more rapidly than has been hitherto thought possible.

ARCH. GEIKIE

ISLAND LIFE [1]

II.

IN the second half of his volume Mr. Wallace proceeds to apply to the elucidation of the history of the characteristic assemblages of plants and animals in islands, the principles laid down with so much explicitness in the first half. He points out that for the purposes of the naturalist a fundamental difference exists between islands that have once formed part of continents and those which have not. Continental islands are those which, by geological revolutions at more or less remote periods, have been severed from the continental masses in their neighbourhood. They are recognisably portions of the continental ridges of the earth's surface. This relation is usually made strikingly apparent by the chart of soundings between them and the nearest mainland (Fig. 2). Further, in geological structure they resemble parts of the continents, like which they contain both old and new formations, with or without volcanic accumulations. In some cases the evidence of recent severance from the adjacent continent is abundant. In others it is less distinct; for example, where the islands are separated from the nearest land by a depression of a thousand fathoms or more, and where their fauna, though abundant, is of a fragmentary nature, almost all the species being distinct, many of them forming distinct and peculiar genera or families, while many of the characteristic continental orders or families are entirely absent, and in their place come animals to which the nearest allies are to be found only in remote parts of the world. Oceanic islands, on the other hand, exhibit no geological connection with any continental area, but owe their birth either to upheaval of the ocean floor or to the piling up of lavas and tuffs round submarine vents of eruption. Their geological structure is of the simplest kind. As Mr. Darwin long ago showed, they consist of volcanic rocks or of coral reefs, or of volcanic and coral-line formations combined. Ancient formations, so characteristic of continental islands, are wholly wanting. These islands lie far removed from a continent, and rise from water of profound depth. Their fauna is in curious keeping with this isolation, for it contains no indigenous land-mammals or amphibians, but abounds in birds and insects, and usually possesses some reptiles. These animals or their ancestors must have reached the islands by crossing the ocean.

Mr. Wallace first attacks the problems presented by the Oceanic Islands (Fig. 1). He describes the characters of the flora and fauna of the Azores, Bermuda, the Galapagos, St. Helena, and the Sandwich Islands, and endeavours in each case to show how the resemblances and differences between them and the plants and animals of the continents may be accounted for. The contrast offered by two groups of islands on either side of the American continent—the Bermudas and Galapagos—brings vividly before the mind the nature of the difficulties with which the author grapples, and the methods by which he seeks to solve them. In the case of the Bermuda group a series of coral islets having a total area of no more than fifty square miles rises from the very deepest depression in the Atlantic basin in 32° N. lat. at a distance of 700 miles from North Carolina. The chief elements in the fauna of these islands are birds and land-shells. Upwards of 180 species of birds have been observed, more than half of which belong to wading and swimming orders, while eighty-five are land-birds, of which twenty species are frequent visitors. Only ten species live as permanent residents on the island, and these are all common North American birds. No bird, and indeed no vertebrate animal, save a species of lizard, is peculiar to Bermuda. The feathered population of the islands is de-

[1] "Island Life; or, the Phenomena and Causes of Insular Faunas and Floras," &c. By Alfred Russel Wallace. (London: Macmillan and Co., 1880.) Continued from p. 359

rived from the North American continent, whence every year, especially during the autumnal storms, numbers of birds are blown out to sea. Most of these no doubt perish, but some succeed in reaching Bermuda. Hence from this constant introduction of fresh individuals there has been no development even of any distinct variety in the avian fauna. The land-shells include twenty species, of which at least four, or about a fourth of the whole, are peculiar. The proportion of peculiar land-shells among the Azores is about a half of the whole number of resident species. It is obvious that these organisms have comparatively feeble and uncertain means of transport as compared with birds. They may be carried only at widely separated and irregular intervals, enclosed in drift-wood from some other island or continent. Hence the conditions for their gradual change under the new circumstances of their insular home are exceptionally favourable. The flora of Bermuda contains a majority of tropical and West Indian plants, and includes a number of species identical with

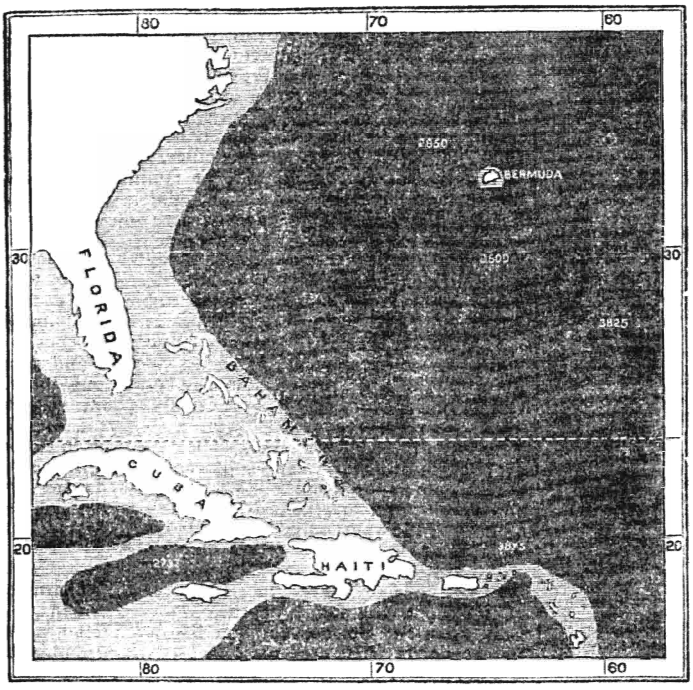

FIG. 1.—Map of Bermuda and the American Coast. The darker tint indicates sea more than 1000 fathoms deep, the lighter shows sea less than 1000 fathoms. The figures mark the depth in fathoms.

those in the Southern States of the American Union. The origin of this vegetation is thus easily traced, first, to the operation of marine currents, whereby plants of the West Indian Islands have been actually observed to be washed ashore on Bermuda and to germinate there; next, of cyclones by which fine seeds transported in the higher parts of the atmosphere may doubtless be easily carried from the American continent; and thirdly, of birds, which among their feathers and in the mud adhering to their feet are known to transport living seeds to enormous distances.

The Galapagos, though less distant from the west side of the American continent than the Bermudas are from the east side, rise nevertheless out of a profoundly deep ocean. The whole group of seventeen islands ranges over an area of 300 miles in length by 200 in breadth, being of volcanic origin, and still containing in the western islands numerous active volcanoes. Between the fauna of the Galapagos however and that of the nearest part of South America a remarkable difference obtains. As usual, no indigenous mammalia or amphibia occur in these islands; but a few species of reptiles abound—land-tortoises, lizards, and snakes, that find their nearest allies on the American continent, whence doubtless their ancestors at some remote period were derived. Out of a total of fifty-seven species of birds no fewer than thirty-eight are peculiar. In particular the land-birds number thirty-one species, which are all, with but one exception, confined to the Galapagos, and more than half of them are so peculiar as to be ranked in distinct genera, though all are undoubtedly allied to birds inhabiting Tropical America. Mr. Wallace points out that every gradation can be traced, from perfect identity with continental species to marked generic divergence, and that "this diversity bears a distinct relation to the probabilities of and facilities for migration to the islands." A species which is widely diffused and essentially migratory will, by frequent arrival of fresh individuals from the parent stock and intercrossing, continue unchanged, while others, in proportion to the rarity of their re-introduction, will be subject to all the variation which change of habitat and prolonged isolation may induce. The flora of these islands includes 174 peculiar flowering-plants, and 158 common to other regions. Among the latter occur forms found both in North and South America, with some that range into the West Indies. Sir Joseph Hooker has observed that the peculiar plants of the Galapagos are allied to forms now found in temperate America, or in the high Andes, while the non-peculiar species are such as live in tropical latitudes near the sea-level. These facts in zoological and botanical distribution the author seeks to explain by the meteorological conditions and geological history of the region. The Galapagos Islands lie in a tract of almost perpetual calms. The storms that annually transport a fresh immigration of birds and seeds to the Bermudas are there unknown; consequently the fauna and flora present a far greater contrast to those of the continent than is the case of Bermuda. The presence of West Indian species is regarded as pointing to the former submergence of the Isthmus of Panama and the consequent drifting of those forms from the north-east, perhaps by a deflected branch of the Gulf Stream. Again, the affinity of a portion of the Galapagos flora to plants of northern or sub-alpine types is looked upon as an indication of that ancient southward migration of northern forms consequent upon the extension of the snow and ice of the Glacial Period.

As examples of Continental Islands the author describes the British Isles, Borneo, Java, Japan, Formosa, and the Madagascar group. The difference between the plants and animals of continental islands and those of the neighbouring continents varies extensively, one main effective element in the case being the length of time during which insular relations have been established. Taking Britain as perhaps the most typical illustration of a large and recently separated continental island (Fig. 2), Mr. Wallace points out how many are the proofs of comparatively recent subsidence, which he regards as the cause of the severance of Britain from the continent. Undoubtedly subsidence was one, probably the principal,

operation whereby the British Islands were isolated. We must not forget however that denudation also played its part. The excavation of the Strait of Dover, for example, may have been in large measure effected by streams diverging from the watershed and partly by the littoral erosion of the waves as they advanced upon the slowly foundering land. The recent date of the separation of Britain is shown by the identity of the fauna as a whole with that of France and Germany. But as compared with the continent, the British Isles are remarkably poor in species. In Germany, for example, there are nearly ninety species of land mammals; even Scandinavia possesses about sixty; but Britain can boast only forty—a number which in Ireland is reduced to twenty-two. Still more remarkable is the contrast presented by the reptiles and amphibia; for while Belgium possesses twenty-two species, Britain can show no more than thirteen, and Ireland has only four. This progressive diminution of the fauna westward is even illustrated by animals possessing the power of flight, though, as might be supposed, it is in these cases less strongly marked. The twelve bats of Britain are reduced to seven in Ireland, the 130 land-birds to about 110. In Britain 1425 species of flowering plants and ferns are known, but in Ireland only 970, or two-thirds of the British flora. The reason assigned by Mr. Wallace for this poverty of species is the extensive submergence of the British Islands during the later stages of the Glacial Period. He believes that the interval between the subsequent elevation and the final separation of Britain from the continent cannot have been of long duration. It was indeed sufficiently prolonged to allow of the migration westwards of a considerable part of the Post-glacial fauna and flora, but the insular condition was established before more than a part had succeeded in reaching Britain, where both the soil and climate would have been eminently favourable for the reception of the rest. The time that has elapsed since our area ceased to be continental has been long enough for the production of a few peculiar varieties. No distinct species or variety of mammal, reptile, or amphibian has arisen. But we possess three peculiar birds—the coal-tit, long-tailed tit, and grouse—fifteen peculiar species of fresh-water fishes, sixty-nine lepidopterous insects, seventy-two beetles, four caddis-flies, and four terrestrial and fluviatile shells believed to be peculiar. In the flora the chief contrasts are exhibited by the mosses and hepaticæ, of which respectively seventeen and nine forms appear to be peculiar. This mode of considering the British fauna and flora brings out in clear relief the relations between them and those of the continent, and their bearings upon the question of the origin of peculiar forms. Not only do the British Islands as a whole contain species or varieties that do not appear on the mainland of Europe, but some of our outlying islands, such as the Shetland Isles, the Isle of Man, and Lundy Island, possess each its local forms that are not met with on the main island.

As "anomalous islands" the author classes together Celebes and New Zealand, the former because it belongs to no one of the six zoological regions of the globe, and cannot be certainly affirmed to have been united to a continent, the latter because in some respects it may be regarded as an oceanic, in others as a continental island. Celebes is supposed by Mr. Wallace to be probably a fragment of Miocene Asia, preserving down to the present time a few remnants of its Tertiary fauna, together with an intermixture of more modern types that have been introduced by ordinary means of dispersal. Three interesting chapters are devoted to New Zealand, and in these is discussed the important question of the origin of the European element in the floras of the temperate southern latitudes.

Enough has been said here to show the nature and value of this new contribution to scientific literature. Even where Mr. Wallace's conclusions may be disputed, they are always of the most suggestive kind. His volume, as he acknowledges, is the development and application of a theory; but it is not written in the spirit of a mere partisan. Its facts are of course marshalled in such form as most effectively to sustain the theory; yet with a transparent directness and honesty of purpose that runs through the whole book, and gives it one of its great charms. The writer does not consciously shut his eyes to any of the difficulties of his case. Candidly admitting them, he presents such explanation as seems to him to offer the most likely pathway to their ultimate solution.

FIG. 2.—Map of the shallow bank connecting the British Isles with the Continent. The dark tint marks sea of more than, the paler tint shows sea of less than, 1000 fathoms in depth. The figures show the depth in fathoms. The narrow channel between Norway and Denmark is 2580 feet deep.

He deserves the thanks alike of geologists and of biologists for a treatise, the appearance of which marks another epoch in the history of the doctrine of Evolution.

ARCH. GEIKIE