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MR. WALLACE'S "ISLAND LIFE."

It is perhaps not generally known that Mr. Wallace shares with Mr. Darwin the honor of having laid the corner-stone of the modern theory of evolution, in the doctrine of "origin of species by variation, struggle for life, and survival of the fittest." On the same day there was read before the Linnean Society two papers, one by Mr. Wallace, on "The tendency of varieties to depart indefinitely from their original type," and the other by Mr. Darwin, on "The tendency of species to form varieties," in both of which this idea was brought out from independent points of view. This fact induced Mr. Darwin to hasten the publication of his epoch-making book, *The Origin of Species.* The principle above stated was therefore undoubtedly developed wholly independently by the two men, but the difference was this: It was struck out by Mr. Wallace as a bare suggestion, a happy thought, a flash of intuitive genius; while in Mr. Darwin's mind it had lain and been worked upon in silence for many years, until it had assumed the form of a consistent theory. In the presence of Mr. Darwin's great work, therefore, Mr. Wallace, with rare modesty, waived all claim as founder of the modern theory of evolution. His friends, however, rightly insist on giving him credit for his wholly original suggestion. It is not surprising, then, that Mr. Wallace has embraced the the theory of evolution with enthusiasm, and made it the basis of all his subsequent work. For more than a century past the diversity of faunas and floras of different countries has been observed and speculated upon; but the facts seemed to be utterly without law and without assignable cause other than the Divine Will, until the theory of evolution furnished the key. The life-work of Mr. Wallace has been, and will be to the end, the investigation of the laws of geographical distribution of species under the light of this theory. In fact, he may almost be said to have created this as a distinct science. The principles upon which Mr. Wallace attempts to solve the problem of geographical distribution of species are: (1.) the tendency of each species to indefinite increase and dispersal; (2.) the tendency of each species to vary slowly, but indefinitely, under the pressure of changing conditions and competitive struggle with other species; (3.) the tendency of migrations, whether voluntary, as in the higher animals, or involuntary, as in the lower animals and in plants, to increase the rate of change by increasing the competitive struggle; (4.) the tendency of isolation to preserve species once formed by preventing invasions by other species. All these may be called evolution principles. But (5.) extensive migrations are enforced by changes of climate and permitted by changes of physical geography, opening gateways previously closed; while isolations of faunas and floras, once formed, are effected by the closing of gateways previously open. Such changes of climate and physical geography, such openings and closings of high-

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ways, and therefore such enforced migrations and isolations, are known to have occurred repeatedly in geological times.

It is evident, therefore, that the problem of the present distribution of species is a very complex one. Its solution involves the discussion of a great variety of collateral questions, and therefore requires the widest comprehensiveness of knowledge. Not only does it require complete mastery of the principles of evolution, but also a knowledge of the more recent geological changes in climate and physical geography; and these last, in their turn, necessitate a discussion of that most difficult subject, the *causes* of geological climates, and especially the causes of the climate of the Great Ice Age. Several years ago Mr. Wallace wrote his great work on "Geographical Distribution of Species," in which all these subjects were taken up and dicussed in a masterly way. The present work is the result of further reflection on the same subject, but taking a wider range and addressed to a larger public. In what follows, we will suppose the reader to be already acquainted with the previous work.

Mr. Wallace's book is divided into two parts. In Part I, he discusses the principles above stated. In Part II, he applies them to the explanation of the phenomena of insular life. Doubtless the first part will create the deeper interest, for there is a wide interest in these general principles aside from their application; but for many there will also be a peculiar charm in the second part.

In the first part, after giving with remarkable clearness the *elementary facts of distribution* on continents, he occupies several chapters in showing how these may be explained by evolution, dispersal, and survival under changing conditions. We cannot follow him here; we will only take one case, as an example. The puzzling phenomenon of discontinuity—*i. e.*, of a genus or a species existing in widely separated localities; as, for example, in England and Japan, or in Asia Minor and China, or in the Eastern States and the Pacific Coast, but not in the intervening region—he explains by survival in isolated spots of species or genera which were once widely diffused and abundant. Similarly explained are cases of a very peculiar genus, with only one or perhaps two species, and found only in one little spot on the earth's surface; as, for example, Sequoias, only two species, Big Tree and Redwood, and found only in California; Sweet Gum, only one species, and found only in the Eastern States. These were once widely diffused all over America and Europe, but are now confined to small, isolated spots. All such species and genera are dying out. We may compare the process to the drying away of an extensive lake, like that which once covered the whole of Nevada, until only small, isolated brine pools are left.

He next discusses the subject of the substantial permanency of the great features of the earth's surface; *viz.*, continents and ocean basins, which he rightly regards as a necessary basis of all safe reasoning on the subject of distribution. The older geologists, following the lead of Lyell, believed that the oscillations of the earth's crust in geological times have been so extreme that continents and ocean bottoms have frequently changed places. But among the most advanced geologists of the present day, both in this country and in England, the conviction is growing that these oscillations were sufficient only to affect the form of the borders of the continents, but not to destroy the continents themselves; that there has been throughout all geological times a gradual development of continents to greater size and hight; that, speaking broadly, continents have always been continents and ocean basins ocean basins. Mr. Wallace adopts this view, but does not give credit, as he ought, to American geologists. The gradual evolution of the American continent is so clear that American geologists, under the leadership of Dana and Agassiz, have for thirty years past held this view. English geologists, on the contrary, are only now waking up to its certainty and importance.

In the next chapter is taken up the subject of changes of geological climate as a cause of migration, and this compels the discussion in the two following chapters of the causes of geological climates, especially of the Great Ice Age, or glacial epoch. Mr. Wallace's discussion of this subject is certainly the most complete and satisfactory we have seen. He accepts Croll's theory—*viz.*, that it was caused by the coincidence of a period of greatest eccentricity of the earth's orbit with an aphelion winter—but supplements it by geographical causes; *viz.*, elevation in high latitude regions. In other words, he combines the two causes which are now admitted to be the most probable. Moreover, he shows that this modification of Croll's theory is not subject to the fatal objections which have been brought against its original form. If the glacial epoch was due to astronomical causes alone, then there must have been frequent recurrences of glacial epochs in geological times, and the followers of Croll have sought diligently for evidences of such. Some bowlder drifts have, indeed, been found in various places and on various geological horizons, which are probably really due to glacial agency; but the testimony of fossils is

so uniformly and demonstrably indicative of warm climates even in polar regions, in all geological periods previous to the glacial epoch, that we are compelled to regard these bowlder drifts of earlier periods as local phenomena confined to the vicinity of high mountains, and, therefore, as not indicative of a glacial epoch. But Mr. Wallace shows that astronomical causes will not produce a glacial epoch without the coöperation of geographical causes, and that these latter have been favorable only for warm and uniform climates in all geological times until the glacial epoch. At that time there was a remarkable coincidence of the highest efficiency of astronomical and geographical causes, and, therefore, the climate of this epoch may be regarded as unique.

During the glacial epoch the great changes of climate enforced migrations north and south, and the attendant changes of physical geography, by opening gateways, permitted migrations in many directions. The result was an intense struggle for mastery of indigenous species with migrants from other regions. The distribution of species at the present time has been the result of these migrations and these struggles. Thus, geological changes are the causes of present distribution; and, conversely, present distribution furnishes the key to the most recent geological changes.

As an example of the operation of these causes, we may take the fauna of Central Africa. This fauna is composed of a mixture of true African indigenes not found elsewhere, with many other species found either in Asia now or abundantly in Europe and Asia in late tertiary times. These latter are by far the most numerous. Now, the explanation is as follows: During tertiary times Africa was a great island-continent isolated by a sea occupying the place of Sahara.

The tertiary fauna of Europe-Asia and of Africa developed independently of each other, and, therefore, with species peculiar to each. By the abolition of the dividing sea (which took place during glacial epoch) and the increasing rigor of the climate the animals of Europe-Asia were driven southward, and in the struggle with the African indigenes which ensued many of the latter were destroyed, and the migrants remained masters of the field, though somewhat changed by the struggle. On the return of more temperate conditions these migrants were prevented from returning northward, and were isolated in Africa by the formation of the desert and the Mediterranean. Meanwhile, such of their relatives of Europe as did not migrate were exterminated by the glacial climate.

In Part II, Mr. Wallace applies these principles to the explanation of the actual distribution of species, confining himself in the present volume to the phenomena of insular life as affording the clearest demonstration. He divides islands into two groups—*viz.*, continental islands and oceanic islands. Continental islands are fragments of continents dissevered mostly by subsidence. Oceanic islands, on the contrary, are built up from mid-ocean bottom by volcanic agency in recent geological times. They are not the highest points of submerged continents as has been supposed, for they never contain any paleozoic or mesozoic rocks, but consist either wholly of volcanic ejections or of these with recent tertiary strata. The character of the fauna and flora also show the same origin, as will presently appear. Of the Indo-Pacific islands, Borneo, Sumatra, Java, etc., are continentals appended to Asia; New Guinea, New Zealand, etc., to Australia; while the small islands which over-dot the mid-Pacific (Polynesian) are oceanic. In the Atlantic Ocean the West Indian and the British Isles are good examples of continentals—the one group belonging to America and the other to Europe—while the Bermudas and the Azores are excellent examples of oceanics.

The fauna and flora of continental islands are allied to those of the neighboring continent, because thence derived, yet more or less differing, because isolated and subject to different conditions; the degree of difference being proportioned to the amount of difference in physical conditions, and the length of time during which these have operated—*i. e.*, the length of time since the isolation was effected. The British Isles are an example of continental islands recently separated, and in which, therefore, the species are nearly, though not wholly, identical with those of the continent. The divergence has in most cases reached only the extent of varieties, and only in a few cases to that of species. Madagascar on the other hand is an admirable example of an island much longer separated. The Madagascar species are very peculiar, and yet decidedly related to what we have called the indigenes of Africa, but not to the African migrants from Europe. Therefore, Madagascar was separated from Africa before the latter was temporarily joined to and received migrants from Europe.

Oceanic islands having originated in mid-ocean in comparatively recent time have no indigenes, but their fauna and flora are made up wholly of species which have come to them as waifs from continents or from other islands. They are, therefore, destitute of mammals and amphibians, except such as have been intro-

duced by man, while their birds are such as reach them by flight, or are carried to them by storms, and their reptiles, insects, and land mollusca reach them on floated logs, or are carried as ova on the feet of birds. The species of oceanic islands are, therefore, waifs from many regions, though usually mostly from some one region, depending on the direction of oceanic currents or of winds; but by isolation these may have been changed so as to make new varieties or new species; or else species may be preserved on these islands which have become extinct in the mother country. Finally, the intrinsic interest of the subject is greatly enhanced, and the value of the work increased by a series of entirely new and really admirable illustrative maps, and especially is this true of the maps of the ocean bottoms about continental islands showing the changes in physical geography which have probably taken place in recent geological times. In a word, the book is one which the intelligent general reader will not neglect and the biologist cannot do without. JOSEPH LE CONTE.