FRONTISPIECE

[Illustration]

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

AUTHOR OF "THE MALAY ARCHIPELAGO," "THE GEOGRAPHICAL DISTRIBUTION OF

ANIMALS,"

"DARWINISM," ETC.

\_SECOND AND REVISED EDITION\_

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TO

SIR JOSEPH DALTON HOOKER,

K.C.S.I., C.B., F.R.S., ETC., ETC.

WHO, MORE THAN ANY OTHER WRITER,

HAS ADVANCED OUR KNOWLEDGE OF THE GEOGRAPHICAL

DISTRIBUTION OF PLANTS, AND ESPECIALLY

OF INSULAR FLORAS,

I Dedicate this Volume;

ON A KINDRED SUBJECT,

AS A TOKEN OF ADMIRATION AND REGARD.

\* \* \* \* \*

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CORRECTIONS IN PRESENT ISSUE.

The first issue of this Edition being exhausted, the opportunity is taken

of making a few corrections, the most important of which are here stated:--

\_Page\_ 163. Statement modified as to supposed glaciation of South Africa.

\_Pages\_ 174 and 338. Many geologists now hold that there was no great

submergence during the glacial epoch. The passages referring to it have

therefore been re-written.

\_Page\_ 182. Colonel Fielden's explanation of the occurrence of large trees

on shores and in recent drift in high latitudes, is now added.

" 272. A species of Carex peculiar to Bermuda is now given.

" 356. \_Geomalacus maculosus\_, as a peculiar British species, is now

omitted.

Verbal alterations have also been made at pages 41, 105, 356, and 360.

\* \* \* \* \*

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PREFACE TO THE SECOND EDITION

This edition has been carefully revised throughout, and owing to the great

increase to our knowledge of the Natural History of some of the islands

during the last twelve years considerable additions or alterations have

been required. The more important of these changes are the following:--

Chapter VII. The account of the migrations of animals and plants during and

since the Glacial Epoch, has been modified to accord with newer

information.

Chapters VIII and IX. The discussion of the causes of Glacial Epochs and

Mild Arctic Climates has been somewhat modified in view of the late Dr.

Croll's remarks, and the argument rendered clearer.

Chapter XIII. Several additions to the Fauna of the Galapagos have been

noted.

Chapter XV. Considerable additions have been made to this chapter embodying

the recent discoveries of birds and insects new to the Sandwich Islands,

while a much fuller account has been given of its highly peculiar and very

interesting flora.

Chapter XVI. Important additions and corrections have been made in the

lists of peculiar British animals and plants embodying the most recent

information.

Chapter XVII. Very large additions have been made to the mammalia and birds

of Borneo, and full lists of the peculiar species are given. {viii}

Chapter XVIII. A more accurate account is given of the birds of Japan.

Chapter XIX. The recent additions to the mammals and birds of Madagascar

are embodied in this chapter, and a fuller sketch is given of the rich and

peculiar flora of the island.

Chapter XXI. and XXII. Some important additions have been made to these

chapters owing to more accurate information as to the depth of the sea

around New Zealand, and to the discovery of abundant remains of fossil

plants of the tertiary and cretaceous periods both in New Zealand and

Australia.

In the body of the work I have in each case acknowledged the valuable

information given me by naturalists of eminence in their various

departments, and I return my best thanks to all who have so kindly assisted

me. I am however indebted in a special manner to one gentleman--Mr. Theo.

D. A. Cockerell, now Curator of the Museum of the Jamaica Institute--who

supplied me with a large amount of information by searching the most recent

works in the scientific libraries, by personal inquiries among naturalists,

and also by giving me the benefit of his own copious notes and

observations. Without his assistance it would have been difficult for me to

have made the present edition so full and complete as I hope it now is. In

a work of such wide range, and dealing with so large a body of facts some

errors will doubtless be detected, though, I trust few of importance.

PARKSTONE, DORSET, \_December, 1891\_.

\* \* \* \* \*

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PREFACE TO THE FIRST EDITION

The present volume is the result of four years' additional thought and

research on the lines laid down in my \_Geographical Distribution of

Animals\_, and may be considered as a popular supplement to and completion

of that work.

It is, however, at the same time a complete work in itself: and, from the

mode of treatment adopted, it will, I hope, be well calculated to bring

before the intelligent reader the wide scope and varied interest of this

branch of natural history. Although some of the earlier chapters deal with

the same questions as my former volumes, they are here treated from a

different point of view; and as the discussion of them is more elementary

and at the same time tolerably full, it is hoped that they will prove both

instructive and interesting. The plan of my larger work required that

\_genera\_ only should be taken account of; in the present volume I often

discuss the distribution of \_species\_, and this will help to render the

work more intelligible to the unscientific reader.

The full statement of the scope and object of the present essay given in

the "Introductory" chapter, together with the "Summary" of the whole work

and the general view of the more important arguments given in the

"Conclusion," render it unnecessary for me to offer any further remarks on

these points. I may, however, state {x} generally that, so far as I am able

to judge, a real advance has here been made in the mode of treating

problems in Geographical Distribution, owing to the firm establishment of a

number of preliminary doctrines or "principles," which in many cases lead

to a far simpler and yet more complete solution of such problems than have

been hitherto possible. The most important of these doctrines are those

which establish and define--(1) The former wide extension of all groups now

discontinuous, as being a necessary result of "evolution"; (2) The

permanence of the great features of the distribution of land and water on

the earth's surface; and, (3) The nature and frequency of climatal changes

throughout geological time.

I have now only to thank the many friends and correspondents who have given

me information or advice. Besides those whose assistance is acknowledged in

the body of the work, I am especially indebted to four gentlemen who have

been kind enough to read over the proofs of chapters dealing with questions

on which they have special knowledge, giving me the benefit of valuable

emendations and suggestions. Mr. Edward R. Alston has looked over those

parts of the earlier chapters which relate to the mammals of Europe and the

North Temperate zone; Mr. S. B. J. Skertchley, of the Geological Survey,

has read the chapters which discuss the glacial epoch and other geological

questions; Professor A. Newton has looked over the passages referring to

the birds of the Madagascar group; while Sir Joseph D. Hooker has given me

the invaluable benefit of his remarks on my two chapters dealing with the

New Zealand flora.

CROYDON, \_August, 1880\_.

\* \* \* \* \*

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ISLAND LIFE

PART I

\_THE DISPERSAL OF ORGANISMS\_

\_ITS PHENOMENA, LAWS, AND CAUSES\_

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CHAPTER I

INTRODUCTORY

Remarkable Contrasts in distribution of Animals--Britain and

Japan--Australia and New Zealand--Bali and Lombok--Florida and Bahama

Islands--Brazil and Africa--Borneo, Madagascar, and Celebes--Problems

in distribution to be found in every country--Can be solved only by the

combination of many distinct lines of inquiry, biological and

physical--Islands offer the best subjects for the study of

distribution--Outline of the subjects to be discussed in the present

volume.

When an Englishman travels by the nearest sea-route from Great Britain to

Northern Japan he passes by countries very unlike his own, both in aspect

and natural productions. The sunny isles of the Mediterranean, the sands

and date-palms of Egypt, the arid rocks of Aden, the cocoa groves of

Ceylon, the tiger-haunted jungles of Malacca and Singapore, the fertile

plains and volcanic peaks of Luzon, the forest-clad mountains of Formosa,

and the bare hills of China, pass successively in review; till after a

circuitous voyage of thirteen thousand miles he finds himself at Hakodadi

in Japan. He is now separated from his starting-point by the whole width of

Europe and Northern Asia, by an almost endless succession of plains and

mountains, arid deserts or icy plateaux, yet when he visits the interior of

the country he sees so many familiar natural objects that he can hardly

help fancying he is close to his home. He finds the woods and fields

tenanted by tits, hedge-sparrows, wrens, wagtails, larks, redbreasts, {4}

thrushes, buntings, and house-sparrows, some absolutely identical with our

own feathered friends, others so closely resembling them that it requires a

practised ornithologist to tell the difference. If he is fond of insects he

notices many butterflies and a host of beetles which, though on close

examination they are found to be distinct from ours, are yet of the same

general aspect, and seem just what might be expected in any part of Europe.

There are also of course many birds and insects which are quite new and

peculiar, but these are by no means so numerous or conspicuous as to remove

the general impression of a wonderful resemblance between the productions

of such remote islands as Britain and Yesso.

Now 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.

But there are some more striking cases even than this, of the diversity of

the productions of countries not far apart. In the Malay Archipelago there

are two islands, named Bali and Lombok, each about as large as Corsica, and

separated 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 megapodes, 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 though a considerable

number of birds are the same in both islands the difference {5} 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.

In the western hemisphere we find equally striking examples. The Eastern

United States possess very peculiar and interesting plants and animals, the

vegetation becoming more luxuriant as we go south but not altering in

essential character, so that when we reach Alabama or Florida we still find

ourselves in the midst of pines, oaks, sumachs, magnolias, vines, and other

characteristic forms of the temperate flora; while the birds, insects, and

land-shells are of the same general character with those found further

north.[1] But if we now cross over the narrow strait, about fifty miles

wide, which separates Florida from the Bahama Islands, we find ourselves in

a totally different country, surrounded by a vegetation which is

essentially tropical and generally identical with that of Cuba. The change

is most striking, because there is little difference of climate, of soil,

or apparently of position, to account for it; and when we find that the

birds, the insects, and especially the land-shells of the Bahamas are

almost all West Indian, while the North American types of plants and

animals have almost all completely disappeared, we shall be convinced that

such differences and resemblances cannot be due to existing conditions, but

must depend upon laws and causes to which mere proximity of position offers

no clue.

Hardly less uncertain and irregular are the effects of climate. Hot

countries usually differ widely 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 {6} Australia are slight and

unimportant as compared with the enormous differences we find when we pass

from the latter country to equally tropical Java. If we compare

corresponding portions of different continents, we find no indication that

the almost perfect similarity of climate and general conditions has any

tendency to produce similarity in the animal world. The equatorial parts of

Brazil and of the West Coast of Africa are almost identical in climate and

in luxuriance of vegetation, but their animal life is totally diverse. In

the former we have tapirs, sloths, and prehensile-tailed monkeys; in the

latter elephants, antelopes, and man-like apes; while among birds, the

toucans, chatterers, and humming-birds of Brazil are replaced by the

plantain-eaters, bee-eaters, and sun-birds of Africa. Parts of

South-temperate America, South Africa, and South Australia, correspond

closely in climate; yet the birds and quadrupeds of these three districts

are as completely unlike each other as those of any parts of the world that

can be named.

If we visit the great islands of the globe, we find that they present

similar anomalies in their animal productions, for while some exactly

resemble the nearest continents others are widely different. Thus the

quadrupeds, birds and insects of Borneo correspond very closely to those of

the Asiatic continent, while those of Madagascar are extremely unlike

African forms, although the distance from the continent is less in the

latter case than in the former. And if we compare the three great islands

Sumatra, Borneo, and Celebes--lying as it were side by side in the same

ocean--we find that the two former, although furthest apart, have almost

identical productions, while the two latter, though closer together, are

more unlike than Britain and Japan situated in different oceans and

separated by the largest of the great continents.

These examples will illustrate the kind of questions it is the object of

the present work to deal with. Every continent, every country, and every

island on the globe, offers similar problems of greater or less complexity

and interest, and the time has now arrived when their solution can be

attempted with some prospect of success. Many {7} years study of this class

of subjects has convinced me that there is no short and easy method of

dealing with them; because they are, in their very nature, the visible

outcome and residual product of the whole past history of the earth. If we

take the organic productions of a small island, or of any very limited

tract of country, such as a moderate-sized country parish, we have, in

their relations and affinities--in the fact that they are \_there\_ and

others are \_not\_ there, a problem which involves all the migrations of

these species and their ancestral forms--all the vicissitudes of climate

and all the changes of sea and land which have affected those

migrations--the whole series of actions and reactions which have determined

the preservation of some forms and the extinction of others,--in fact the

whole history of the earth, inorganic and organic, throughout a large

portion of geological time.

We shall perhaps better exhibit the scope and complexity of the subject,

and show that any intelligent study of it was almost impossible till quite

recently, if we concisely enumerate the great mass of facts and the number

of scientific theories or principles which are necessary for its

elucidation.

We require then in the first place an adequate knowledge of the fauna and

flora of the whole world, and even a detailed knowledge of many parts of

it, including the islands of more special interest and their adjacent

continents. This kind of knowledge is of very slow growth, and is still

very imperfect;[2] and in many cases it can {8} never now be obtained owing

to the reckless destruction of forests and with them of countless species

of plants and animals. In the next place we require a true and natural

classification of animals and plants, so that we may know their real

affinities; and it is only now that this is being generally arrived at. We

further have to make use of the theory of "descent with modification" as

the only possible key to the interpretation of the facts of distribution,

and this theory has only been generally accepted within the last twenty

years. It is evident that, so long as the belief in "special creations" of

each species prevailed, no explanation of the complex facts of distribution

\_could\_ be arrived at or even conceived; for if each species was created

where it is now found no further inquiry can take us beyond that fact, and

there is an end of the whole matter. Another important factor in our

interpretation of the phenomena of distribution, is a knowledge of the

extinct forms that have inhabited each country during the tertiary and

secondary periods of geology. New facts of this kind are daily coming to

light, but except as regards Europe, North America, and parts of India,

they are extremely scanty; and even in the best-known countries the record

itself is often very defective and fragmentary. Yet we have already

obtained remarkable evidence of the migrations of many animals and plants

in past ages, throwing an often unexpected light on the actual distribution

of many groups.[3] By this means alone can we obtain positive evidence of

the past migrations of organisms; and when, as too frequently is the case,

this is altogether wanting, we {9} have to trust to collateral evidence and

more or less probable hypothetical explanations. Hardly less valuable is

the evidence of stratigraphical geology; for this often shows us what parts

of a country have been submerged at certain epochs, and thus enables us to

prove that certain areas have been long isolated and the fauna and flora

allowed time for special development. Here, too, our knowledge is

exceedingly imperfect, though the blanks upon the geological map of the

world are yearly diminishing in extent. Lastly, as a most valuable

supplement to geology, we require to know approximately, the depth and

contour of the ocean-bed, since this affords an important clue to the

former existence of now-submerged lands, uniting islands to continents, or

affording intermediate stations which have aided the migrations of many

organisms. This kind of information has only been partially obtained during

the last few years; and it will be seen in the latter part of this volume,

that some of the most recent deep-sea soundings have afforded a basis for

an explanation of one of the most difficult and interesting questions in

geographical biology--the origin of the fauna and flora of New Zealand.

Such are the various classes of evidence that bear directly on the question

of the distribution of organisms; but there are others of even a more

fundamental character, and the importance of which is only now beginning to

be recognised by students of nature. These are, firstly, the wonderful

alterations of climate which have occurred in the temperate and polar

zones, as proved by the evidences of glaciation in the one and of luxuriant

vegetation in the other; and, secondly, the theory of the permanence of

existing continents and oceans. If glacial epochs in temperate lands and

mild climates near the poles have, as now believed by men of eminence,

occurred several times over in the past history of the earth, the effects

of such great and repeated changes, both on the migration, modification,

and extinction, of species, must have been of overwhelming importance--of

more importance perhaps than even the geological changes of sea and land.

It is therefore necessary to consider the evidence for these climatal

changes; {10} and then, by a critical examination of their possible causes,

to ascertain whether they were isolated phenomena, were due to recurrent

cosmical actions, or were the result of a great system of terrestrial

development. The latter is the conclusion we arrive at; and this conclusion

brings with it the conviction, that in the theory which accounts for both

glacial epochs and warm polar climates, we have the key to explain and

harmonize many of the most anomalous biological and geological phenomena,

and one which is especially valuable for the light it throws on the

dispersal and existing distribution of organisms. The other important

theory, or rather corollary from the preceding theory--that of the

permanence of oceans and the general stability of continents throughout all

geological time, is as yet very imperfectly understood, and seems, in fact,

to many persons in the nature of a paradox. The evidence for it, however,

appears to me to be conclusive; and it is certainly the most fundamental

question in regard to the subject we have to deal with: since, if we once

admit that continents and oceans may have changed places over and over

again (as many writers maintain), we lose all power of reasoning on the

migrations of ancestral forms of life, and are at the mercy of every wild

theorist who chooses to imagine the former existence of a now-submerged

continent to explain the existing distribution of a group of frogs or a

genus of beetles.

As already shown by the illustrative examples adduced in this chapter, some

of the most remarkable and interesting facts in the distribution and

affinities of organic forms are presented by islands in relation to each

other and to the surrounding continents. The study of the productions of

the Galapagos--so peculiar, and yet so decidedly related to the American

continent--appears to have had a powerful influence in determining the

direction of Mr. Darwin's researches into the origin of species; and every

naturalist who studies them has always been struck by the unexpected

relations or singular anomalies which are so often found to characterize

the fauna and flora of islands. Yet their full importance in connection

with the history of the earth and its inhabitants has hardly yet {11} been

recognised; and it is in order to direct the attention of naturalists to

this most promising field of research, that I restrict myself in this

volume to an elucidation of some of the problems they present to us. By far

the larger part of the islands of the globe are but portions of continents

undergoing some of the various changes to which they are ever subject; and

the correlative proposition, that every portion of our continents has again

and again passed through insular conditions, has not been sufficiently

considered, but is, I believe, the statement of a great and most suggestive

truth, and one which lies at the foundation of all accurate conception of

the physical and organic changes which have resulted in the present state

of the earth.

The indications now given of the scope and purpose of the present volume

renders it evident that, before we can proceed to the discussion of the

remarkable phenomena presented by insular faunas and floras, and the

complex causes which have produced them, we must go through a series of

preliminary studies, adapted to give us a command of the more important

facts and principles on which the solution of such problems depends. The

succeeding eight chapters will therefore be devoted to the explanation of

the mode of distribution, variation, modification, and dispersal, of

species and groups, illustrated by facts and examples; of the true nature

of geological change as affecting continents and islands; of changes of

climate, their nature, causes, and effects; of the duration of geological

time and the rate of organic development.

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{12}

CHAPTER II

THE ELEMENTARY FACTS OF DISTRIBUTION

Importance of Locality as an essential character of Species--Areas of

Distribution--Extent and Limitations of Specific Areas--Specific range

of Birds--Generic Areas--Separate and overlapping areas--The species of

Tits as illustrating Areas of Distribution--The distribution of the

species of Jays--Discontinuous generic areas--Peculiarities of generic

and family distribution--General features of overlapping and

discontinuous areas--Restricted areas of Families--The distribution of

Orders.

So long as it was believed that the several species of animals and plants

were "special creations," and had been formed expressly to inhabit the

countries in which they are now found, their habitat was an ultimate fact

which required no explanation. It was assumed that every animal was

\_exactly\_ adapted to the climate and surroundings amid which it lived, and

that the only, or, at all events, the chief reason why it did not inhabit

another country was, that the climate or general conditions of that country

were not suitable to it, but in what the unsuitability consisted we could

rarely hope to discover. Hence the exact locality of any species was not

thought of much importance from a scientific point of view, and the idea

that anything could be learnt by a comparative study of different floras

and faunas never entered the minds of the older naturalists.

But so soon as the theory of evolution came to be generally adopted, and it

was seen that each animal could only have come into existence in some area

where ancestral {13} forms closely allied to it already lived, a real and

important relation was established between an animal and its native

country, and a new set of problems at once sprang into existence. From the

old point of view the \_diversities\_ of animal life in the separate

continents, even where physical conditions were almost identical, was the

fact that excited astonishment; but seen by the light of the evolution

theory, it is the \_resemblances\_ rather than the diversities in these

distant continents and islands that are most difficult to explain. It thus

comes to be admitted that a knowledge of the exact area occupied by a

species or a group is a real portion of its natural history, of as much

importance as its habits, its structure, or its affinities; and that we can

never arrive at any trustworthy conclusions as to how the present state of

the organic world was brought about, until we have ascertained with some

accuracy the general laws of the distribution of living things over the

earth's surface.

\_Areas of Distribution.\_--Every species of animal has a certain area of

distribution to which, as a rule, it is permanently confined, although, no

doubt, the limits of its range fluctuate somewhat from year to year, and in

some exceptional cases may be considerably altered in a few years or

centuries. Each species is moreover usually limited to one continuous area,

over the whole of which it is more or less frequently to be met with, but

there are many apparent and some real exceptions to this rule. Some animals

are so adapted to certain kinds of country--as to forests or marshes,

mountains or deserts--that they cannot, permanently, live elsewhere. These

may be found scattered over a wide area in suitable spots only, but can

hardly on that account be said to have several distinct areas of

distribution. As an example we may name the chamois, which lives only on

high mountains, but is found in the Pyrenees, the Alps, the Carpathians, in

some of the Greek mountains and the Caucasus. The variable hare is another

and more remarkable case, being found all over Northern Europe and Asia

beyond lat. 55Â°, and also in Scotland and Ireland. In central Europe it is

unknown till we come to the Alps, the Pyrenees, and the Caucasus, where it

again appears. This is one of the best cases known of the {14}

discontinuous distribution of a \_species\_, there being a gap of about a

thousand miles between its southern limits in Russia, and its reappearance

in the Alps. There are of course numerous instances in which species occur

in two or more islands, or in an island and continent, and are thus

rendered discontinuous by the sea, but these involve questions of changes

in sea and land which we shall have to consider further on. Other cases are

believed to exist of still wider separation of a species, as with the marsh

titmice and the reed buntings of Europe and Japan, where similar forms are

found in the extreme localities, while distinct varieties or sub-species,

inhabit the intervening districts.

\_Extent and Limitations of Specific Areas.\_--Leaving for the present these

cases of want of continuity in a species, we find the most wide difference

between the extent of country occupied, varying in fact from a few square

miles to almost the entire land surface of the globe. Among the mammalia,

however, the same species seldom inhabits both the old and new worlds,

unless they are strictly arctic animals, as the reindeer, the elk, the

arctic fox, the glutton, the ermine, and some others. The common wolf of

Europe and Northern Asia is thought by many naturalists to be identical

with the variously coloured wolves of North America extending from the

Arctic Ocean to Mexico, in which case this will have perhaps the widest

range of any species of mammal. Little doubt exists as to the identity of

the brown bears and the beavers of Europe and North America; but all these

species range up to the arctic circle, and there is no example of a mammal

universally admitted to be identical yet confined to the temperate zones of

the two hemispheres. Among the undisputed species of mammalia the leopard

has an enormous range, extending all over Africa and South Asia to Borneo

and the east of China, and thus having probably the widest range of any

known mammal. The winged mammalia have not usually very wide ranges, there

being only one bat common to the Old and New Worlds. This is a British

species, \_Vesperugo serotinus\_, which is found over the larger part of

North America, Europe and Asia, as far {15} as Pekin, and even extends into

tropical Africa, thus rivalling the leopard and the wolf in the extent of

country it occupies.

Of very restricted ranges there are many examples, but some of these are

subject to doubts as to the distinctness of the species or as to its

geographical limits being really known. In Europe we have a distinct

species of ibex (\_Capra Pyrenaica\_) confined to the Pyrenean mountains,

while the true marmot is restricted to the Alpine range. More remarkable is

the Pyrenean water-mole (\_Mygale Pyrenaica\_), a curious small insectivorous

animal found only in a few places in the northern valleys of the Pyrenees.

In islands there are many cases of undoubted restriction of species to a

small area, but these involve a different question from the range of

species on continents where there is no \_apparent\_ obstacle to their wider

extension.

\_Specific range of Birds.\_--Among birds we find instances of much wider

range of species, which is only what might be expected considering their

powers of flight; but, what is very curious, we also find more striking

(though perhaps not more frequent) examples of extreme limitation of range

among birds than among mammals. Of the former phenomenon perhaps the most

remarkable case is that afforded by the osprey or fishing-hawk, which

ranges over the greater portion of all the continents, as far as Brazil,

South Africa, the Malay Islands, and Tasmania. The barn owl (\_Strix

flammea\_) has nearly as wide a range, but in this case there is more

diversity of opinion as to the specific difference of many of the forms

inhabiting remote countries, some of which seem undoubtedly to be distinct.

Among passerine birds the raven has probably the widest range, extending

from the arctic regions to Texas and New Mexico in America, and to North

India and Lake Baikal in Asia; while the little northern willow-wren

(\_Phylloscopus borealis\_) ranges from arctic Norway across Asia to Alaska,

and southward to Ceylon, China, Borneo, and Timor.

Of very restricted continental ranges the best examples in Europe are, the

little blue magpie (\_Cyanopica cooki\_) confined to the central portions of

the Spanish peninsula; and the Italian sparrow found only in Italy and

Corsica. {16} In Asia, Palestine affords some examples of birds of very

restricted range--a beautiful sun-bird (\_Nectarinea osea\_) a peculiar

starling (\_Amydrus tristramii\_) and some others, being almost or quite

confined to the warmer portions of the valley of the Jordan. In the

Himalayas there are numbers of birds which have very restricted ranges, but

those of the Neilgherries are perhaps better known, several species of

laughing thrushes and some other birds being found only on the summits of

these mountains. The most wonderfully restricted ranges are, however, to be

found among the humming-birds of tropical America. The great volcanic peaks

of Chimborazo and Pichincha have each a peculiar species of humming-bird

confined to a belt just below the limits of perpetual snow, while the

extinct volcano of Chiriqui in Veragua has a species confined to its wooded

crater. One of the most strange and beautiful of the humming-birds

(\_Loddigesia mirabilis\_) was obtained once only, more than forty years ago,

near Chachapoyas in the Andes of northern Peru; and though Mr. Gould sent

many drawings of the bird to people visiting the district and for many

years offered a high reward for a specimen, no other has ever been seen![4]

The above details will sufficiently explain what is meant by the "specific

area" or range of a species. The very wide and very narrow ranges are

exceptional, the great majority of species both of mammals and birds

ranging over moderately wide areas, which present no striking contrasts in

climate and physical conditions. Thus a large proportion of European birds

range over the whole continent in an east and west direction, but

considerable numbers are restricted either to the northern or the southern

half. In Africa some species range over all the continent south of the

desert, while large numbers are restricted to the equatorial forests, or to

the upland plains. In North America, if we exclude the tropical and the

arctic portions, a considerable number of species range over all the

temperate parts of the continent, while still {17} more are restricted to

the east, the centre, or the west, respectively.

\_Generic Areas.\_--Having thus obtained a tolerably clear idea of the main

facts as to the distribution of isolated species, let us now consider those

collections of closely-allied species termed genera. What a genus is will

be sufficiently understood by a few illustrations. All the different kinds

of dogs, jackals, and wolves belong to the dog genus, Canis; the tiger,

lion, leopard, jaguar, and the wild cats, to the cat genus, Felis; the

blackbird, song-thrush, missel-thrush, fieldfare, and many others to the

thrush genus, Turdus; the crow, rook, raven, and jackdaw, to the crow

genus, Corvus; but the magpie belongs to another, though closely-allied

genus, Pica, distinguished by the different form and proportions of its

wings and tail from all the species of the crow genus. The number of

species in a genus varies greatly, from one up to several hundreds. The

giraffe, the glutton, the walrus, the bearded reedling, the secretary-bird,

and many others, have no close allies, and each forms a genus by itself.

The beaver genus, Castor, and the camel genus, Camelus, each consist of two

species. On the other hand, the deer genus, Cervus has forty species; the

mouse and rat genus, Mus more than a hundred species; and there is about

the same number of the thrush genus; while among the lower classes of

animals genera are often very extensive, the fine genus Papilio, or

swallow-tailed butterflies, containing more than four hundred species; and

Cicindela, which includes our native tiger beetles, has about the same

number. Many genera of shells are very extensive, and one of them--the

genus Helix, including the commonest snails, and ranging all over the

world--is probably the most extensive in the animal kingdom, numbering

about two thousand described species.[5]

\_Separate and Overlapping Areas.\_--The species of a genus are distributed

in two ways. Either they occupy distinct areas which do not touch each

other and are sometimes widely separated, or they touch and occasionally

overlap {18} each other, each species occupying an area of its own which

rarely coincides exactly with that of any other species of the same genus.

In some cases, when a river, a mountain-chain, or a change of conditions as

from pasture to desert or forest, determines the range of species, the

areas of two species of the same genus may just meet, one beginning where

the other ends; but this is comparatively rare. It occurs, however, in the

Amazon valley, where several species of monkeys, birds, and insects come up

to the south bank of the river but do not pass it, while allied species

come to the north bank, which in like manner forms their boundary. As

examples we may mention that one of the Saki monkeys (\_Pithecia monachus?\_)

comes up to the south bank of the Upper Amazon, while immediately we cross

over to the north bank we find another species (\_Pithecia rufibarbata?\_).

Among birds we have the green jacamar (\_Galbula viridis\_), abundant on the

north bank of the Lower Amazon, while on the south bank we have two allied

species (\_Galbula rufoviridis\_ and \_G. cyaneicollis\_); and among insects we

have at Santarem on the south bank of the Amazon, the beautiful blue

butterfly, \_Callithea sapphira\_, while almost opposite to it, at

Monte-alegre, an allied species, \_Callithea Leprieuri\_ is alone found.

Perhaps the most interesting and best known case of a series of allied

species, whose ranges are separate but conterminous, is that of the

beautiful South American wading birds, called trumpeters, and forming the

genus Psophia. There are five species, all found in the Amazon valley, but

each limited to a well-marked district bounded by great rivers. On the

north bank of the Amazon there are two species, one in its lower valley

extending up to the Rio Negro; and the other in the central part of the

valley beyond that river; while to the south of the Amazon there are three,

one above the Madeira, one below it, and a third near Para, probably

separated from the last by the Tocantins river.

Overlapping areas among the species of a genus is a more common phenomenon,

and is almost universal where these species are numerous in the same

continent. It is, however, exceedingly irregular, so that we often find one

{19} species extending over a considerable portion of the area occupied by

the genus and including the entire areas of some of the other species. So

little has been done to work out accurately the limits of species that it

is very difficult to give examples. One of the best is to be found in the

genus \_Dendroeca\_, a group of American wood-warblers. These little birds

all migrate in the winter into the tropical regions, but in the summer they

come north, each having its particular range. Thus, \_D. dominica\_ comes as

far as the middle Eastern States, \_D. coerulea\_ keeps west of the

Alleghanies, \_D. discolor\_ comes to Michigan and New England; four other

species go farther north in Canada, while several extend to the borders of

the Arctic zone.

\_The Species of Tits as Illustrating Areas of Distribution.\_--In our own

hemisphere the overlapping of allied species may be well illustrated by the

various kinds of titmice, constituting the genus Parus, several of which

are among our best known English birds. The great titmouse (\_Parus major\_)

has the widest range of all, extending from the Arctic circle to Algeria,

Palestine, and Persia, and from Ireland right across Siberia to the Ochotsk

sea, probably following the great northern forest belt. It does not extend

into China and Japan, where distinct species are found. Next in extent of

range is the coal tit (\_Parus ater\_) which inhabits all Europe from the

Mediterranean to about 64Â° N. latitude, in Asia Minor to the Lebanon and

Caucasus, and across Siberia to Amoorland and Japan. The marsh tit (\_Parus

palustris\_) inhabits temperate and south Europe from 61Â° N. latitude in

Norway to Poland and South-west Russia, and in the south from Spain to Asia

Minor. Closely allied to this--of which it is probably only a variety or

sub-species--is the northern marsh tit (\_Parus borealis\_), which overlaps

the last in Norway and Sweden, and also in South Russia and the Alps, but

extends further north into Lapland and North Russia, and thence probably in

a south-easterly direction across Central Asia to North China. Yet another

closely-allied species (\_Parus camtschatkensis\_) ranges from North-eastern

Russia across Northern Siberia to Lake Baikal and to Hakodadi in Japan,

thus overlapping \_Parus borealis\_ in the {20} western portion of its area.

Our little favourite, the blue tit (\_Parus coeruleus\_) ranges over all

Europe from the Arctic circle to the Mediterranean, and on to Asia Minor

and Persia, but does not seem to pass beyond the Ural mountains. Its lovely

eastern ally the azure tit (\_Parus cyaneus\_) overlaps the range of \_P.

coeruleus\_ in Western Europe as far as St. Petersburg and Austria, rarely

straggling to Denmark, while it stretches all across Central Asia between

the latitudes 35Â° and 56Â° N. as far as the Amoor valley. Besides these

wide-ranging species there are several others which are more restricted.

\_Parus teneriffÃ¦\_, a beautiful dark blue form of our blue tit, inhabits

North-west Africa and the Canaries; \_Parus ledouci\_, closely allied to our

coal tit, is found only in Algeria; \_Parus lugubris\_, allied to the marsh

tit, is confined to South-east Europe and Asia Minor, from Hungary and

South Russia to Palestine; and \_Parus cinctus\_, another allied form, is

confined to the extreme north in Lapland, Finland, and perhaps Northern

Russia and Siberia. Another beautiful little bird, the crested titmouse

(\_Parus cristatus\_) is sometimes placed in a separate genus. It inhabits

nearly all Central and South Europe, wherever there are pine forests, from

64Â° N. latitude to Austria and North Italy, and in the west to Spain and

Gibraltar, while in the east it does not pass the Urals and the Caucasus

range. Its nearest allies are in the high Himalayas.

These are all the European tits, but there are many others inhabiting Asia,

Africa, and North America; so that the genus Parus has a very wide range,

in Asia to Ceylon and the Malay Islands, in Africa to the Cape, and in

North America to the highlands of Mexico.

\_The Distribution of the Species of Jays.\_--Owing to the very wide range of

several of the tits, the uncertainty of the specific distinction of others,

and the difficulty in many cases of ascertaining their actual distribution,

it has not been found practicable to illustrate this genus by means of a

map. For this purpose we have chosen the genus Garrulus or the jays, in

which the species are less numerous, the specific areas less extensive, and

the species generally better defined; while being large and handsome {21}

birds they are sure to have been collected, or at least noticed, wherever

they occur. There are, so far as yet known, twelve species of true jays,

occupying an area extending from Western Europe to Eastern Asia and Japan,

and nowhere passing the Arctic circle to the north, or the tropic of Cancer

to the south, so that they constitute one of the most typical of the

PalÃ¦arctic[6] genera. The following are the species, beginning with the

most westerly and proceeding towards the east. The numbers prefixed to each

species correspond to those on the coloured map which forms the

frontispiece to this volume.

1. \_Garrulus glandarius.\_--The common jay, inhabits the British Isles and

all Europe except the extreme north, extending also into North Africa,

where it has been observed in many parts of Algeria. It occurs near

Constantinople, but apparently not in Asia Minor; and in Russia, up to, but

not beyond, the Urals. The jays being woodland birds are not found in open

plains or barren uplands, and their distribution is hence by no means

uniform within the area they actually occupy.

2. \_Garrulus cervicalis.\_--The Algerian jay, is a very distinct species

inhabiting a limited area in North Africa, and found in some places along

with the common species.

3. \_Garrulus krynicki.\_--The black-headed jay, is closely allied to the

common species, but quite distinct, inhabiting a comparatively small area

in South-eastern Europe, and Western Asia.

4. \_Garrulus atricapillus.\_--The Syrian jay, is very closely allied to the

last, and inhabits an adjoining area in Syria, Palestine, and Southern

Persia.

5. \_Garrulus hyrcanus.\_--The Persian jay, is a small species allied to our

jay and only known from the Elburz Mountains in the north of Persia.

6. \_Garrulus brandti.\_--Brandt's jay, is a very distinct species, having an

extensive range across Asia from the Ural Mountains to North China,

Mandchuria, and the northern island of Japan, and also crossing the Urals

into {22} Russia where it has been found as far west as Kazan in districts

where the common jay also occurs.

7. \_Garrulus lanceolatus.\_--The black-throated jay, is a very distinct form

known only from the North-western Himalayas and Nepal, common about Simla,

and extending into Cashmere beyond the range of the next species.

8. \_Garrulus bispecularis.\_--The Himalayan jay is also very distinct,

having the head coloured like the back, and not striped as in all the

western species. It inhabits the Himalayas east of Cashmere, but is more

abundant in the western than the eastern division, though according to the

AbbÃ© David it reaches Moupin in East Thibet.

9. \_Garrulus sinensis.\_--The Chinese jay, is very closely allied to the

Himalayan, of which it is sometimes classed as a sub-species. It seems to

be found in all the southern mountains of China, from Foochow on the east

to Sze-chuen and East Thibet on the west, as it is recorded from Moupin by

the AbbÃ© David as well as the Himalayan bird--a tolerable proof that it is

a distinct form.

10. \_Garrulus taivanus.\_--The Formosan jay is a very close ally of the

preceding, confined to the island of Formosa.

11. \_Garrulus japonicus.\_--The Japanese jay is nearly allied to our common

British species, being somewhat smaller and less brightly coloured, and

with black orbits; yet these are the most widely separated species of the

genus. According to Mr. Seebohm this species is equally allied to the

Chinese and Siberian jays.

In the accompanying map (see frontispiece) we have laid down the

distribution of each species so far as it can be ascertained from the works

of Sharpe and Dresser for Europe, Jerdon for India, Swinhoe for China, and

Mr. Seebohm's recent work for Japan. There is, however, much uncertainty in

many places, and gaps have to be filled up conjecturally, while such a

large part of Asia is still very imperfectly explored, that considerable

modifications may have to be made when the country becomes more accurately

known. But though details may be modified we can hardly suppose that the

great features of the several specific areas, or their relations to each

other {23} will be much affected; and these are what we have chiefly to

consider as bearing on the questions here discussed.

The first thing that strikes us on looking at the map, is, the small amount

of overlapping of the several areas, and the isolation of many of the

species; while the next most striking feature is the manner in which the

Asiatic species almost surround a vast area in which no jays are found. The

only species with large areas, are the European \_G. glandarius\_ and the

Asiatic \_G. Brandti\_. The former has three species overlapping it--in

Algeria, in South-eastern and North-eastern Europe respectively. The Syrian

jay (No. 4), is not known to occur anywhere with the black-headed jay (No.

3), and perhaps the two areas do not meet. The Persian jay (No. 5), is

quite isolated. The Himalayan and Chinese jays (Nos. 7, 8, and 9) form a

group which are isolated from the rest of the genus; while the Japanese jay

(No. 11), is also completely isolated as regards the European jays to which

it is nearly allied. These peculiarities of distribution are no doubt in

part dependent on the habits of the jays, which live only in well-wooded

districts, among deciduous trees, and are essentially non-migratory in

their habits, though sometimes moving southwards in winter. This will

explain their absence from the vast desert area of Central Asia, but it

will not account for the gap between the North and South Chinese species,

nor for the absence of jays from the wooded hills of Turkestan, where Mr.

N. A. Severtzoff collected assiduously, obtaining 384 species of birds but

no jay. These peculiarities, and the fact that jays are never very abundant

anywhere, seem to indicate that the genus is now a decaying one, and that

it has at no very distant epoch occupied a larger and more continuous area,

such as that of the genus Parus at the present day.

\_Discontinuous generic Areas.\_--It is not very easy to find good examples

of genera whose species occupy two or more quite disconnected areas, for

though such cases may not be rare, we are seldom in a position to mark out

the limits of the several species with sufficient accuracy. The best and

most remarkable case among European birds is {24} that of the blue magpies,

forming the genus Cyanopica. One species (\_C. cooki\_) is confined (as

already stated) to the wooded and mountainous districts of Spain and

Portugal, while the only other species of the genus (\_C. cyanus\_) is found

far away in North-eastern Asia and Japan, so that the two species are

separated by about 5,000 miles of continuous land. Another case is that of

the curious little water-moles forming the genus Mygale, one species \_M.

muscovitica\_, being found only on the banks of the Volga and Don in

South-eastern Russia, while the other, \_M. pyrenaica\_, is confined to

streams on the northern side of the Pyrenees. In tropical America there are

four different kinds of bell-birds belonging to the genus Chasmorhynchus,

each of which appears to inhabit a restricted area completely separated

from the others. The most northerly is \_C. tricarunculatus\_ of Costa Rica

and Veragua, a brown bird with a white head and three long caruncles

growing upwards at the base of the beak. Next comes \_C. variegatus\_, in

Venezuela, a white bird with a brown head and numerous caruncles on the

throat, perhaps conterminous with the last; in Guiana, extending to near

the mouth of the Rio Negro, we have \_C. niveus\_, the bell-bird described by

Waterton, which is pure white, with a single long fleshy caruncle at the

base of the beak; the last species, \_C. nudicollis\_, inhabits South-east

Brazil, and is also white, but with black stripes over the eyes, and with a

naked throat. These birds are about the size of thrushes, and are all

remarkable for their loud, ringing notes, like a bell or a blow on an

anvil, as well as for their peculiar colours. They are therefore known to

the native Indians wherever they exist, and we may be the more sure that

they do not spread over the intervening areas where they have never been

found, and where the natives know nothing of them.

A good example of isolated species of a group nearer home, is afforded by

the snow-partridges of the genus Tetraogallus. One species inhabits the

Caucasus range and nowhere else, keeping to the higher slopes from 6,000 to

11,000 feet above the sea, and accompanying the ibex in its wanderings, as

both feed on the same plants. Another {25} has a wider range in Asia Minor

and Persia, from the Taurus mountains to the South-east corner of the

Caspian Sea; a third species inhabits the Western Himalayas, between the

forests and perpetual snow, extending eastwards to Nepal; while a fourth is

found on the north side of the mountains in Thibet, and the ranges of these

two perhaps overlap; the last species inhabit the Altai mountains, and like

the two first appears to be completely separated from all its allies.

There are some few still more extraordinary cases in which the species of

one genus are separated in remote continents or islands. The most striking

of these is that of the tapirs, forming the genus Tapirus, of which there

are two or three species in South America, and one very distinct species in

Malacca and Borneo, separated by nearly half the circumference of the

globe. Another example among quadrupeds is a peculiar genus of moles named

Urotrichus, of which one species inhabits Japan and the other British

Columbia. The cuckoo-like honey-guides, forming the genus Indicator, are

tolerably abundant in tropical Africa, but there are two outlying species,

one in the Eastern Himalaya mountains, the other in Borneo, both very rare,

and recently an allied species has been found in the Malay peninsula. The

beautiful blue and green thrush-tits forming the genus Cochoa, have two

species in the Eastern Himalayas and Eastern China, while the third is

confined to Java; the curious genus Eupetes, supposed to be allied to the

dippers, has one species in Sumatra and Malacca, while four other species

are found two thousand miles distant in New Guinea; lastly, the lovely

ground-thrushes of the genus Pitta, range from Hindostan to Australia,

while a single species, far removed from all its near allies, inhabits West

Africa.

\_Peculiarities of Generic, and Family Distribution.\_--The examples now

given sufficiently illustrate the mode in which the several species of a

genus are distributed. We have next to consider genera as the component

parts of families, and families of orders, from the same point of view.

{26}

All the phenomena presented by the species of a genus are reproduced by the

genera of a family, and often in a more marked degree. Owing, however, to

the extreme restriction of genera by modern naturalists, there are not many

among the higher animals that have a world-wide distribution. Among the

mammalia there is no such thing as a truly cosmopolitan genus. This is

owing to the absence of all the higher orders except the mice from

Australia, while the genus Mus, which occurs there, is represented by a

distinct group, Hesperomys, in America. If, however, we consider the

Australian dingo as a native animal we might class the genus Canis as

cosmopolite, but the wild dogs of South America are now formed into

separate genera by some naturalists. Many genera, however, range over three

or more continents, as Felis (the cat genus) absent only from Australia;

Ursus (the bear genus) absent from Australia and tropical Africa; Cervus

(the deer genus) with nearly the same range; and Sciurus (the squirrel

genus) found in all the continents but Australia. Among birds Turdus, the

thrush, and Hirundo, the swallow genus, are the only perching birds which

are truly cosmopolites; but there are many genera of hawks, owls, wading

and swimming birds, which have a world-wide range.

As a great many genera consist of single species there is no lack of cases

of great restriction, such as the curious lemur called the "potto," which

is found only at Sierra Leone, and forms the genus Perodicticus; the true

chinchillas found only in the Andes of Peru and Chili south of 9Â° S. lat.

and between 8,000 and 12,000 feet elevation; several genera of finches each

confined to limited portions of the higher Himalayas, the blood-pheasants

(Ithaginis) found only above 10,000 feet from Nepal to East Thibet; the

bald-headed starling of the Philippine islands, the lyre-birds of East

Australia, and a host of others.

It is among the different genera of the same family that we meet with the

most striking examples of discontinuity, although these genera are often as

unmistakably allied as are the species of a genus; and it is these cases

that furnish the most interesting problems to the student of distribution.

{27} We must therefore consider them somewhat more fully.

Among mammalia the most remarkable of these divided families is that of the

camels, of which one genus Camelus, the true camels, comprising the camel

and dromedary, is confined to Asia, while the other Auchenia, comprising

the llamas and alpacas, is found only in the high Andes and in the plains

of temperate South America. Not only are these two genera separated by the

Atlantic and by the greater part of the land of two continents, but one is

confined to the Northern and the other to the Southern hemisphere. The next

case, though not so well known, is equally remarkable; it is that of the

CentetidÃ¦, a family of small insectivorous animals, which are wholly

confined to Madagascar and the large West Indian islands Cuba and Hayti,

the former containing five genera and the latter a single genus with a

species in each island. Here again we have the whole continent of Africa as

well as the Atlantic ocean separating allied genera. Two families (or

subfamilies) of rat-like animals, OctodontidÃ¦ and EchimyidÃ¦, are also

divided by the Atlantic. Both are mainly South American, but the former has

two genera in North and East Africa, and the latter also two in South and

West Africa. Two other families of mammalia, though confined to the Eastern

hemisphere, are yet markedly discontinuous. The TragulidÃ¦ are small

deer-like animals, known as chevrotains or mouse-deer, abundant in India

and the larger Malay islands and forming the genus Tragulus; while another

genus, Hyomoschus, is confined to West Africa. The other family is the

SimiidÃ¦ or anthropoid apes, in which we have the gorilla and chimpanzee

confined to West and Central Africa, while the allied orangs are found only

in the islands of Sumatra and Borneo, the two groups being separated by a

greater space than the EchimyidÃ¦ and other rodents of Africa and South

America.

Among birds and reptiles we have several families, which, from being found

only within the tropics of Asia, Africa, and America, have been termed

tropicopolitan groups. The MegalÃ¦midÃ¦ or barbets are gaily coloured {28}

fruit-eating birds, almost equally abundant in tropical Asia and Africa,

but less plentiful in America, where they probably suffer from the

competition of the larger sized toucans. The genera of each country are

distinct, but all are closely allied, the family being a very natural one.

The trogons form a family of very gorgeously coloured and remarkable

insect-eating birds very abundant in tropical America, less so in Asia, and

with a single genus of two species in Africa.

Among reptiles we have two families of snakes--the DendrophidÃ¦ or

tree-snakes, and the DryiophidÃ¦ or green whip-snakes--which are also found

in the three tropical regions of Asia, Africa, and America, but in these

cases even some of the genera are common to Asia and Africa, or to Africa

and America. The lizards forming the family AmphisbÃ¦nidÃ¦ are divided

between tropical Africa and America, a few species only occurring in the

southern portion of the adjacent temperate regions; while even the

peculiarly American family of the iguanas is represented by two genera in

Madagascar, and one in the Fiji and Friendly Islands. Passing on to the

Amphibians the worm-like CÃ¦ciliadÃ¦ are tropicopolitan, as are also the

toads of the family EngystomatidÃ¦. Insects also furnish some analogous

cases, three genera of CicindelidÃ¦, (Pogonostoma, Ctenostoma, and

Peridexia) showing a decided connection between this family in South

America and Madagascar; while the beautiful family of diurnal moths,

UraniidÃ¦, is confined to the same two countries. A somewhat similar but

better known illustration is afforded by the two genera of ostriches, one

confined to Africa and Arabia, the other to the plains of temperate South

America.

\_General features of Overlapping and Discontinuous Areas.\_--These numerous

examples of discontinuous genera and families form an important section of

the facts of animal dispersal which any true theory must satisfactorily

account for. In greater or less prominence they are to be found all over

the world, and in every group of animals, and they grade imperceptibly into

those cases of conterminous and overlapping areas which we have seen to

{29} prevail in most extensive groups of species, and which are perhaps

even more common in those large families which consist of many closely

allied genera. A sufficient proof of the overlapping of generic areas is

the occurrence of a number of genera of the same family together. Thus in

France or Italy about twenty genera of warblers (SylviadÃ¦) are found, and

as each of the thirty-three genera of this family inhabiting temperate

Europe and Asia has a different area, a great number must here overlap. So,

in most parts of Africa, at least ten or twelve genera of antelopes may be

found, and in South America a large proportion of the genera of monkeys of

the family CebidÃ¦ occur in many districts; and still more is this the case

with the larger bird families, such as the tanagers, the tyrant shrikes, or

the tree-creepers, so that there is in all these extensive families no

genus whose area does not overlap that of many others. Then among the

moderately extensive families we find a few instances of one or two genera

isolated from the rest, as the spectacled bear, Tremarctos, found only in

Chili, while the remainder of the family extends from Europe and Asia over

North America to the Mountains of Mexico, but no further south; the BovidÃ¦,

or hollow-horned ruminants, which have a few isolated genera in the Rocky

Mountains and the islands of Sumatra and Celebes; and from these we pass on

to the cases of wide separation already given.

\_Restricted Areas of Families.\_--As families sometimes consist of single

genera and even single species, they often present examples of very

restricted range; but what is perhaps more interesting are those cases in

which a family contains numerous species and sometimes even several genera,

and yet is confined to a narrow area. Such are the golden moles

(ChrysochloridÃ¦) consisting of two genera and three species, confined to

extratropical South Africa; the hill-tits (LiotrichidÃ¦), a family of

numerous genera and species mainly confined to the Himalayas, but with a

few straggling species in the Malay countries and the mountains of China;

the PteroptochidÃ¦, large wren-like birds, consisting of eight genera and

nineteen species, almost entirely confined to temperate South America and

{30} the Andes; and the birds-of-paradise, consisting of nineteen or twenty

genera and about thirty-five species, almost all inhabitants of New Guinea

and the immediately surrounding islands, while a few, doubtfully belonging

to the family, extend to East Australia. Among reptiles the most striking

case of restriction is that of the rough-tailed burrowing snakes

(UropeltidÃ¦), the five genera and eighteen species being strictly confined

to Ceylon and the southern parts of the Indian Peninsula.

\_The Distribution of Orders.\_--When we pass to the larger groups, termed

orders, comprising several families, we find comparatively few cases of

restriction and many of worldwide distribution; and the families of which

they are composed are strictly comparable to the genera of which families

are composed, inasmuch as they present examples of overlapping, or

conterminous, or isolated areas, though the latter are comparatively rare.

Among mammalia the Insectivora offer the best example of an order, several

of whose families inhabit areas more or less isolated from the rest; while

the Marsupialia have six families in Australia, and one, the opossums, far

off in America.

Perhaps, more important is the limitation of some entire orders to certain

well-defined portions of the globe. Thus the Proboscidea, comprising the

single family and genus of the elephants, and the Hyracoidea, that of the

Hyrax or Syrian coney, are confined to parts of Africa and Asia; the

Marsupials to Australia and America; and the Monotremata, the lowest of all

mammals--comprising the duck-billed Platypus and the spiny Echidna, to

Australia and New Guinea. Among birds the Struthiones or ostrich tribe are

almost confined to the three Southern continents, South America, Africa and

Australia; and among Amphibia the tailed Batrachia--the newts and

salamanders--are similarly restricted to the northern hemisphere.

These various facts will receive their explanation in a future chapter.

\* \* \* \* \*

[Illustration]

{31}

CHAPTER III

CLASSIFICATION OF THE FACTS OF DISTRIBUTION.--ZOOLOGICAL REGIONS

The Geographical Divisions of the Globe do not correspond to Zoological

divisions--The range of British Mammals as indicating a Zoological

Region--Range of East Asian and North African Mammals--The Range of

British Birds--Range of East Asian Birds--The limits of the PalÃ¦arctic

Region--Characteristic features of the PalÃ¦arctic Region--Definition

and characteristic groups of the Ethiopian Region--Of the Oriental

Region--Of the Australian Region--Of the Nearctic Region--Of the

Neotropical Region--Comparison of Zoological Regions with the

Geographical Divisions of the Globe.

Having now obtained some notion of how animals are dispersed over the

earth's surface, whether as single species or as collected in those groups

termed genera, families, and orders, it will be well, before proceeding

further, to understand something of the classification of the facts we have

been considering, and some of the simpler conclusions these facts lead to.

We have hitherto described the distribution of species and groups of

animals by means of the great geographical divisions of the globe in common

use; but it will have been observed that in hardly any case do these define

the limits of anything beyond species, and very seldom, or perhaps never,

even those accurately. Thus the term "Europe" will not give, with any

approach to accuracy, the range of any one genus of mammals or birds, and

{32} perhaps not that of half-a-dozen species. Either they range into

Siberia, or Asia Minor, or Palestine, or North Africa; and this seems to be

always the case when their area of distribution occupies a large portion of

Europe. There are, indeed, a few species limited to Central or Western or

Southern Europe, and these are almost the only cases in which we can use

the word for zoological purposes without having to add to it some portion

of another continent. Still less useful is the term Asia for this purpose,

since there is probably no single animal or group confined to Asia which is

not also more or less nearly confined to the tropical or the temperate

portion of it. The only exception is perhaps the tiger, which may really be

called an Asiatic animal, as it occupies nearly two-thirds of the

continent; but this is an unique example, while the cases in which Asiatic

animals and groups are strictly limited to a portion of Asia, or extend

also into Europe or into Africa or to the Malay Islands, are exceedingly

numerous. So, in Africa, very few groups of animals range over the whole of

it without going beyond either into Europe or Asia Minor or Arabia, while

those which are purely African are generally confined to the portion south

of the tropic of Cancer. Australia and America are terms which better serve

the purpose of the zoologist. The former defines the limit of many

important groups of animals; and the same may be said of the latter, but

the division into North and South America introduces difficulties, for

almost all the groups especially characteristic of South America are found

also beyond the isthmus of Panama, in what is geographically part of the

northern continent.

It being thus clear that the old and popular divisions of the globe are

very inconvenient when used to describe the range of animals, we are

naturally led to ask whether any other division can be made which will be

more useful, and will serve to group together a considerable number of the

facts we have to deal with. Such a division was made by Mr. P. L. Sclater

more than twenty years ago, and it has, with some slight modifications,

come into pretty general use in this country, and to some extent also {33}

abroad; we shall therefore proceed to explain its nature and the principles

on which it is established, as it will have to be often referred to in

future chapters of this work, and will take the place of the old

geographical divisions whose inconvenience has already been pointed out.

The primary zoological divisions of the globe are called "regions," and we

will begin by ascertaining the limits of the region of which our own

country forms a part.

\_The Range of British Mammals as indicating a Zoological Region.\_--We will

first take our commonest wild mammalia and see how far they extend, and

especially whether they are confined to Europe or range over parts of other

continents:

1. Wild Cat | Europe | N. Africa | Siberia, Afghanistan.

2. Fox | Europe | N. Africa | Central Asia to Amoor.

3. Weasel | Europe | N. Africa | Central Asia to Amoor.

4. Otter | Europe | N. Africa | Siberia.

5. Badger | Europe | N. Africa | Central Asia to Amoor.

6. Stag | Europe | N. Africa | Central Asia to Amoor.

7. Hedgehog | Europe | -- | Central Asia to Amoor.

8. Mole | Europe | -- | Central Asia.

9. Squirrel | Europe | -- | Central Asia to Amoor.

10. Dormouse | Europe | -- | --

11. Water-rat | Europe | -- | Central Asia to Amoor.

12. Hare | Europe | -- | W. Siberia, Persia.

13. Rabbit | Europe | N. Africa | --

We thus see that out of thirteen of our commonest quadrupeds only one is

confined to Europe, while seven are found also in Northern Africa, and

eleven range into Siberia, most of them stretching quite across Asia to the

valley of the Amoor on the extreme eastern side of that continent. Two of

the above-named British species, the fox and weasel, are also inhabitants

of the New World, being as common in the northern parts of North America as

they are with us; but with these exceptions the entire range of our

commoner species is given, and they clearly show that all Northern Asia and

Northern Africa must be added to Europe in order to form the region which

they collectively inhabit. If now we go into Central Europe and take, for

example, the quadrupeds of Germany, we shall find that these too, although

much more numerous, are confined to the same limits, except that some of

the {34} more arctic kinds, as already stated, extend into the colder

regions of North America.

\_Range of East Asian and North African Mammals.\_--Let us now pass to the

other side of the great northern continent, and examine the list of the

quadrupeds of Amoorland, in the same latitude as Germany. We find that

there are forty-four terrestrial species (omitting the bats, the seals, and

other marine animals), and of these no less than twenty-six are identical

with European species, and twelve or thirteen more are closely allied

representatives, leaving only five or six which are peculiarly Asiatic. We

can hardly have a more convincing proof of the essential oneness of the

mammalia of Europe and Northern Asia.

In Northern Africa we do not find so many European species (though even

here they are very numerous) because a considerable number of West Asiatic

and desert forms occur. Having, however, shown that Europe and Western Asia

have almost identical animals, we may treat all these as really European,

and we shall then be able to compare the quadrupeds of North Africa with

those of Europe and West Asia. Taking those of Algeria as the best known,

we find that there are thirty-three species identical with those of Europe

and West Asia, while twenty-four more, though distinct, are closely allied,

belonging to the same genera; thus making a total of fifty-seven of

European type. On the other hand, we have seven species which are either

identical with species of tropical Africa or allied to them, and six more

which are especially characteristic of the African and Asiatic deserts

which form a kind of neutral zone between the temperate and tropical

regions. If now we consider that Algeria and the adjacent countries

bordering the Mediterranean form part of Africa, while they are separated

from Europe by a wide sea and are only connected with Asia by a narrow

isthmus, we cannot but feel surprised at the wonderful preponderance of the

European and West Asiatic elements in the mammalia which inhabit the

district.

\_The Range of British Birds.\_--As it is very important that no doubt should

exist as to the limits of the zoological {35} region of which Europe forms

a part, we will now examine the birds, in order to see how far they agree

in their distribution with the mammalia. Of late years great attention has

been paid to the distribution of European and Asiatic birds, many

ornithologists having travelled in North Africa, in Palestine, in Asia

Minor, in Persia, in Siberia, in Mongolia, and in China; so that we are now

able to determine the exact ranges of many species in a manner that would

have been impossible a few years ago. These ranges are given for all

British species in the new edition of Yarrell's \_History of British Birds\_

edited by Professor Newton, while those of all European birds are given in

still more detail in Mr. Dresser's beautiful work on the birds of Europe.

In order to confine our examination within reasonable limits, and at the

same time give it the interest attaching to familiar objects, we will take

the whole series of British Passeres or perching birds given in Professor

Newton's work (118 in number) and arrange them in series according to the

extent of their range. These include not only the permanent residents and

regular migrants to our country, but also those which occasionally straggle

here, so that it really comprises a large proportion of all European birds.

I. BRITISH BIRDS WHICH EXTEND TO NORTH AFRICA AND CENTRAL OR NORTH-EAST

ASIA.

1. \_Lanius collurio\_ Red backed Shrike (also all Africa).

2. \_Oriolus Galbula\_ Golden Oriole (also all Africa).

3. \_Turdus musicus\_ Song-Thrush.

4. ,, \_iliacus\_ Red-wing.

5. ,, \_pilaris\_ Fieldfare.

6. \_Monticola saxatilis\_ Blue rock Thrush.

7. \_Ruticilla suecica\_ Bluethroat (also India in winter).

8. \_Saxicola rubicola\_ Stonechat (also India in winter).

9. ,, \_oenanthe\_ Wheatear (also N. America).

10. \_Acrocephalus arundinaceus\_ Great Reed-Warbler.

11. \_Sylvia curruca\_ Lesser Whitethroat.

12. \_Parus major\_ Great Titmouse.

13. \_Motacilla sulphurea\_ Grey Wagtail (also China and Malaya).

14. ,, \_raii\_ Yellow Wagtail.

15. \_Anthus trivialis\_ Tree Pipit.

16. ,, \_spiloletta\_ Water Pipit.

17. ,, \_campestris\_ Tawny Pipit.

18. \_Alauda arvensis\_ Skylark.

19. ,, \_cristata\_ Crested Lark.

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20. \_Emberiza schoeniclus\_ Reed Bunting.

21. ,, \_citrinella\_ Yellow-hammer.

22. \_Fringilla montifringilla\_ Brambling.

23. \_Passer montanus\_ Tree Sparrow (also S. Asia).

24. ,, \_domesticus\_ House Sparrow.

25. \_Coccothraustes vulgaris\_ Hawfinch.

26. \_Carduelis spinus\_ Siskin (also China).

27. \_Loxia curvirostra\_ Crossbill.

28. \_Sturnus vulgaris\_ Starling.

29. \_Pyrrhocorax graculus\_ Chough.

30. \_Corvus corone\_ Crow.

31. \_Hirundo rustica\_ Swallow (all Africa and Asia).

32. \_Cotyle riparia\_ Sand Martin (also India and N. America).

II. BRITISH BIRDS WHICH RANGE TO CENTRAL OR NORTH-EAST ASIA.

1. \_Lanius excubitor\_ Great Grey Shrike.

2. \_Turdus varius\_ White's Thrush (also to Japan).

3. ,, \_atrigularis\_ Black-throated Thrush.

4. \_Acrocephalus nÃ¦vius\_ Grasshopper Warbler.

5. \_Phylloscopus superciliosus\_ Yellow-browed Warbler.

6. \_Certhia familiaris\_ Tree-creeper.

7. \_Parus coeruleus\_ Blue Titmouse.

8. ,, \_ater\_ Coal Titmouse.

9. ,, \_palustris\_ Marsh Titmouse.

10. \_Acredula caudata\_ Long-tailed Titmouse.

11. \_Ampelis garrulus\_ Wax-wing.

12. \_Anthus richardi\_ Richard's Pipit.

13. \_Alauda alpestris\_ Shore Lark (also N. America).

14. \_Plectrophanes nivalis\_ Snow-Bunting (also N. America).

15. ,, \_lapponicus\_ Lapland Bunting.

16. \_Emberiza rustica\_ Rustic Bunting (also China).

17. ,, \_pusilla\_ Little Bunting.

18. \_Linota linaria\_ Mealy Redpole (also N. America).

19. \_Pyrrhula erythrina\_ Scarlet Grosbeak (also N. India, China).

20. ,, \_enucleator\_ Pine Grosbeak (also N. America).

21. \_Loxia bifasciata\_ Two-barred Crossbill.

22. \_Pastor roseus\_ Rose-coloured Starling (also India).

23. \_Corvus corax\_ Raven (also N. America).

24. \_Pica rustica\_ Magpie.

25. \_Nucifraga caryocatactes\_ Nutcracker.

III. BRITISH BIRDS RANGING INTO N. AFRICA AND W. ASIA.

1. \_Lanius minor\_ Lesser Grey Shrike.

2. ,, \_auriculatus\_ Woodchat (also Tropical Africa).

3. \_Muscicapa grisola\_ Spotted Flycatcher (also E. and S.

Africa).

4. ,, \_atricapilla\_ Pied Flycatcher (also Central Africa).

5. Turdus \_viscivorus\_ Mistletoe-Thrush (N. India in winter).

6. ,, \_merula\_ Blackbird.

7. ,, \_torquatus\_ Ring Ouzel.

8. \_Accentor modularis\_ Hedge Sparrow.

9. \_Erithacus rubecula\_ Redbreast.

10. \_Daulias luscinia\_ Nightingale.

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11. \_Ruticilla phÃ¦nicurus\_ Redstart.

12. ,, \_tithys\_ Black Redstart.

13. \_Saxicola rubetra\_ Whinchat.

14. \_AÃ«don galactodes\_ Rufous Warbler.

15. \_Acrocephalus streperus\_ Reed Warbler.

16. ,, \_schÃ¦nobenus\_ Sedge Warbler.

17. \_Melizophilus undatus\_ Dartford Warbler.

18. \_Sylvia rufa\_ Greater Whitethroat.

19. ,, \_salicaria\_ Garden Warbler.

20. ,, \_atricapilla\_ Blackcap.

21. ,, \_orphea\_ Orphean Warbler.

22. \_Phylloscopus sibilatrix\_ Wood Wren.

23. ,, \_trochilus\_ Willow Wren.

24. ,, \_collybita\_ Chiffchaff.

25. \_Regulus cristatus\_ Golden-crested Wren.

26. ,, \_ignicapillus\_ Fire-crested Wren.

27. \_Troglodytes parvulus\_ Wren.

28. \_Sitta cÃ¦sia\_ Nuthatch.

29. \_Motacilla alba\_ White Wagtail (also W. Africa).

30. ,, \_flava\_ Blue-headed Wagtail.

31. \_Anthus pratensis\_ Meadow-Pipit.

32. \_Alauda arborea\_ Woodlark.

33. \_Calandrella brachydactyla\_ Short-toed Lark.

34. \_Emberiza miliaria\_ Common Bunting.

35. ,, \_cirlus\_ Cirl Bunting.

36. ,, \_hortulana\_ Ortolan.

37. \_Fringilla coelebs\_ Chaffinch.

38. \_Coccothraustes chloris\_ Greenfinch.

39. \_Serinus hortulanus\_ Serin.

40. \_Carduelis elegans\_ Goldfinch.

41. \_Linota cannabina\_ Linnet.

42. \_Corvus monedula\_ Jackdaw.

43. \_Chelidon urbica\_ House-Martin.

IV. BRITISH BIRDS RANGING TO NORTH AFRICA.

1. \_Hypolais icterina\_ Icterine Warbler.

2. \_Acrocephalus aquaticus\_ Aquatic Warbler.

3. ,, \_luscinioides\_ Savi's Warbler.

4. \_Motacilla lugubris\_ Pied Wagtail.

5. \_Pyrrhula europÃ¦a\_ Bullfinch.

6. \_Garrulus glandarius\_ Jay.

V. BRITISH BIRDS RANGING TO WEST ASIA ONLY.

1. \_Accentor collaris\_ Alpine Accentor.

2. \_Muscicapa parva\_ Red-breasted Flycatcher (to N. W.

India).

3. \_Panurus biarmicus\_ Bearded Titmouse.

4. \_Melanocorypha sibirica\_ White-winged Lark.

5. \_Euspiza melanocephala\_ Black-headed Bunting.

6. \_Linota flavirostris\_ Twite.

7. \_Corvus frugilegus\_ Rook.

VI. BRITISH BIRDS CONFINED TO EUROPE.

1. \_Cinclus aquaticus\_ Dipper (closely allied races inhabit

other parts of the PalÃ¦arctic Region).

2. \_Parus cristatus\_ Crested Titmouse.

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3. \_Anthus obscurus\_ Rock Pipit.

4. \_Linota rufescens\_ Lesser Redpoll (closely allied races in

N. Asia and N. America).

5. \_Loxia pityopsittacus\_ Parrot Crossbill (a closely allied form

in N. Asia).

We find, that out of a total of 118 British Passeres there are:

32 species which range to North Africa and Central or East Asia.

25 species which range to Central or East Asia, but not to North

Africa.

43 species which range to North Africa and Western Asia.

6 species which range to North Africa, but not at all into Asia.

7 species which range to West Asia, but not to North Africa.

5 species which do not range out of Europe.

These figures agree essentially with those furnished by the mammalia, and

complete the demonstration that all the temperate portions of Asia and

North Africa must be added to Europe to form a natural zoological division

of the earth. We must also note how comparatively few of these overpass the

limits thus indicated; only seven species extending their range

occasionally into tropical or South Africa, eight into some parts of

tropical Asia, and six into arctic or temperate North America.

\_Range of East Asian Birds.\_--To complete the evidence we only require to

know that the East Asiatic birds are as much like those of Europe, as we

have already shown to be the case when we take the point of departure from

our end of the continent. This does not follow necessarily, because it is

possible that a totally distinct North Asiatic fauna might there prevail;

and, although our birds go eastward to the remotest parts of Asia, their

birds might not come westward to Europe. The birds of Eastern Siberia have

been carefully studied by Russian naturalists and afford us the means of

making the required comparison. There are 151 species belonging to the

orders Passeres and PicariÃ¦ (the perching and climbing birds), and of these

no less than 77, or more than half, are absolutely identical {39} with

European species; 63 are peculiar to North Asia, but all except five or six

of these are allied to European forms; the remaining 11 species are

migrants from South-eastern Asia. The resemblance is therefore equally

close whichever extremity of the Euro-Asiatic continent we take as our

starting point, and is equally remarkable in birds as in mammalia. We have

now only to determine the limits of this, our first zoological region,

which has been termed the "PalÃ¦arctic" by Mr. Sclater, meaning the

"northern old-world" region--a name now well known to naturalists.

\_The Limits of the PalÃ¦arctic Region.\_--The boundaries of this region, as

nearly as they can be ascertained, are shown on our general map at the

beginning of this chapter, but it will be evident on consideration, that,

except in a few places, its limits can only be approximately defined. On

the north, east, and west it extends to the ocean, and includes a number of

islands whose peculiarities will be pointed out in a subsequent chapter; so

that the southern boundary alone remains, but as this runs across the

entire continent from the Atlantic to the Pacific ocean, often traversing

little-known regions, we may perhaps never be able to determine it

accurately, even if it admits of such determination. In drawing the

boundary line across Africa we meet with our first difficulty. The

Euro-Asiatic animals undoubtedly extend to the northern borders of the

Sahara, while those of tropical Africa come up to its southern margin, the

desert itself forming a kind of sandy ocean between them. Some of the

species on either side penetrate and even cross the desert, but it is

impossible to balance these with any accuracy, and it has therefore been

thought best, as a mere matter of convenience, to consider the geographical

line of the tropic of Cancer to form the boundary. We are thus enabled to

define the PalÃ¦arctic region as including all north temperate Africa; and,

a similar intermingling of animal types occurring in Arabia, the same

boundary line is continued to the southern shore of the Persian Gulf.

Persia and Afghanistan undoubtedly belong to the PalÃ¦arctic region, and

Baluchistan should probably go with these. The boundary in the

north-western part of India is again difficult to determine, but it {40}

cannot be far one way or the other from the river Indus as far up as

Attock, opposite the mouth of the Cabool river. Here it will bend to the

south-east, passing a little south of Cashmeer, and along the southern

slopes of the Himalayas into East Thibet and China, at heights varying from

9,000 to 11,000 feet according to soil, aspect, and shelter. It may,

perhaps, be defined as extending to the upper belt of forests as far as

coniferous trees prevail; but the temperate and tropical faunas are here so

intermingled that to draw any exact parting line is impossible. The two

faunas are, however, very distinct. In and above the pine woods there are

abundance of warblers of northern genera, with wrens, numerous titmice, and

a great variety of buntings, grosbeaks, bullfinches and rosefinches, all

more or less nearly allied to the birds of Europe and Northern Asia; while

a little lower down we meet with a host of peculiar birds allied to those

of tropical Asia and the Malay Islands, but often of distinct genera. There

can be no doubt, therefore, of the existence here of a pretty sharp line of

demarkation between the temperate and tropical faunas, though this line

will be so irregular, owing to the complex system of valleys and ridges,

that in our present ignorance of much of the country it cannot be marked in

detail on any map.

Further east in China it is still more difficult to determine the limits of

the region, owing to the great intermixture of migrating birds; tropical

forms passing northwards in summer as far as the Amoor river, while the

northern forms visit every part of China in winter. From what we know,

however, of the distribution of some of the more typical northern and

southern species, we are able to fix the limits of the PalÃ¦arctic region a

little south of Shanghai on the east coast. Several tropical genera come as

far north as Ningpo or even Shanghai, but rarely beyond; while in Formosa

and Amoy tropical forms predominate. Such decidedly northern forms as

bullfinches and hawfinches are found at Shanghai; hence we may commence the

boundary line on the coast between Shanghai and Ningpo, but inland it

probably bends a little southward, and then northward to the mountains and

valleys of West {41} China and East Thibet in about 32Â° N. latitude; where,

at Moupin, a French missionary, PÃ¨re David, made extensive collections

showing this district to be at the junction of the tropical and temperate

faunas. Japan, as a whole, is decidedly PalÃ¦arctic, although its extreme

southern portion, owing to its mild insular climate and evergreen

vegetation, gives shelter to a number of tropical forms.

\_Characteristic Features of the PalÃ¦arctic Region.\_--Having thus

demonstrated the unity of the PalÃ¦arctic region by tracing out the

distribution of a large proportion of its mammalia and birds, it only

remains to show how far it is characterised by peculiar groups such as

genera and families, and to say a few words on the lower forms of life

which prevail in it.

Taking first the mammalia, we find this region distinguished by possessing

two peculiar genera of TalpidÃ¦ or moles, the family being confined to the

PalÃ¦arctic and Nearctic regions. The true hedgehogs (Erinaceus) are also

characteristic, being only found elsewhere in South Africa and in the

northern part of the Oriental region. Among Carnivora, the racoon-dog

(Nyctereutes) of North-eastern Asia, and the true badgers of the genus

Meles are peculiar, most other parts of the world possessing distinct

genera of badgers. It has six peculiar genera, or subgenera, of deer; seven

peculiar genera of BovidÃ¦, chiefly antelopes; while the entire group of

goats and sheep, comprising twenty-two species, is almost confined to it,

one species only occurring in the Rocky mountains of North America and

another in the Nilgiris of Southern India. Among the rodents there are nine

genera with twenty-seven species wholly confined to it, while several

others, as the hamsters, the dormice, and the pikas, have only a few

species elsewhere.

In birds there are a large number of peculiar genera of which we need

mention only a few of the more important, as the grass-hopper warblers

(Locustella) with seven species, the Accentors with twelve species, and

about a dozen other genera of warblers, including the robins; the bearded

titmouse and several allied genera; the long-tailed titmice forming the

genus Acredula; the magpies, choughs, and nut-crackers; a host of finches,

among which the bullfinches (Pyrrhula) and the buntings (Emberiza) are the

{42} most important. The true pheasants (Phasianus) are wholly PalÃ¦arctic,

except one species in Formosa, as are several genera of wading birds.

Though the reptiles of cold countries are few as compared with those of the

tropics, the PalÃ¦arctic region in its warmer portions has a considerable

number, and among these are many which are peculiar to it. Such are four

genera of snakes, seven of lizards, five of frogs and toads, and twelve of

newts and salamanders; while of fresh-water fishes there are about twenty

peculiar genera.[7] Among insects we may mention the elegant Apollo

butterflies of the Alps as forming a peculiar genus (Parnassius), only

found elsewhere in the Rocky Mountains of North America, while the

beautiful genus Thais of the south of Europe and Sericinus of North China

are equally remarkable. Among other insects we can only now refer to the

great family of CarabidÃ¦, or predaceous ground-beetles, which are immensely

numerous in this region, there being about fifty peculiar genera; while the

large and handsome genus Carabus, with its allies Procerus and Procrustes,

containing nearly 300 species, is almost wholly confined to this region,

and would alone serve to distinguish it zoologically from all other parts

of the globe.

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Having given so full an exposition of the facts which determine the extent

and boundaries of the PalÃ¦arctic region, there is less need of entering

into much detail as regards the other regions of the Eastern Hemisphere;

their boundaries being easily defined, while their forms of animal life are

well marked and strongly contrasted.

\_Definition and Characteristic Groups of the Ethiopian Region.\_--The

Ethiopian region consists of all tropical and south Africa, to which are

appended the large island of Madagascar and the Mascarene Islands to the

east and north of it, though these differ materially from the continent,

and will have to be discussed in a separate chapter. For the present, then,

we will take Africa south of the tropic of Cancer, and consider how far its

animals are distinct from those of the PalÃ¦arctic region.

Taking first the mammalia, we find the following remarkable animals at once

separating it from the PalÃ¦arctic and every other region. The gorilla and

chimpanzee, the baboons, numerous lemurs, the spotted hyÃ¦na, the aard-wolf

and hyÃ¦na-dog, zebras, the hippopotamus, giraffe, and more than seventy

peculiar antelopes. Here we have a wonderful collection of large and

peculiar quadrupeds, but the Ethiopian region is also characterised by the

absence of others which are not only abundant in the PalÃ¦arctic region but

in many tropical regions as well. The most remarkable of these deficiencies

are the bears the deer and the wild oxen, all of which abound in the

tropical parts of Asia while bears and deer extend into both North and

South America. Besides the large and conspicuous animals mentioned above,

Africa possesses a number of completely isolated groups; such are the

potamogale, a curious otter-like water-shrew, discovered by Du Chaillu in

West Africa, so distinct as to constitute a new family, PotamogalidÃ¦; the

goldenmoles, also forming a peculiar family, ChrysochloridÃ¦; as do the

elephant-shrews, MacroscelididÃ¦; the singular aard-varks, or earth-pigs,

forming a peculiar family of Edentata called OrycteropodidÃ¦; while there

are numerous peculiar genera of monkeys, swine, civets, and rodents.

Among birds the most conspicuous and remarkable are, the great-billed

vulture-crows (Corvultur), the long-tailed {44} whydah finches (Vidua), the

curious ox-peckers (Buphaga), the splendid metallic starlings

(Lamprocolius), the handsome plantain-eaters (Musophaga), the

ground-hornbills (Bucorvus), the numerous guinea-fowls belonging to four

distinct genera, the serpent-eating secretary-bird (Serpentarius), the huge

boat-billed heron (BalÃ¦niceps), and the true ostriches. There are also

three quite peculiar African families, the MusophagidÃ¦ or plantain-eaters,

including the elegant crested touracos; the curious little finch-like

colies (ColiidÃ¦), and the IrrisoridÃ¦, insect-eating birds allied to the

hoopoes but with glossy metallic plumage and arboreal habits.

In reptiles, fishes, insects, and land-shells, Africa is very rich, and

possesses an immense number of peculiar forms. These are not sufficiently

familiar to require notice in a work of this character, but we may mention

a few as mere illustrations: the puff-adders, the most hideous of poisonous

snakes; the chameleons, the most remarkable of lizards; the

goliath-beetles, the largest and handsomest of the CetoniidÃ¦; and some of

the AchatinÃ¦, which are the largest of all known land-shells.

\_Definition and Characteristic Groups of the Oriental Region.\_--The

Oriental region comprises all Asia south of the PalÃ¦arctic limits, and

along with this the Malay Islands as far as the Philippines, Borneo, and

Java. It was called the Indian region by Mr. Sclater, but this term has

been objected to because the Indo-Chinese and Malayan districts are the

richest and most characteristic, while the peninsula of India is the

poorest portion of it. The name "Oriental" has therefore been adopted in my

work on \_The Geographical Distribution of Animals\_ as preferable to either

Malayan or Indo-Australian, both of which have been proposed, but are

objectionable, as being already in use in a different sense.

The great features of the mammals of the Oriental region are, the

long-armed apes, the orang-utans, the tiger, the sun-bears and honey-bears,

the tapir, the chevrotains or mouse-deer, and the Indian elephant. Its most

conspicuous birds are the immense number and variety of babbling-thrushes

(TimaliidÃ¦), its beautiful little hill-tits (LiotrichidÃ¦), its green

bulbuls (PhyllornithidÃ¦), its many varieties {45} of the crow-family, its

beautiful gapers and pittas adorned with the most delicate colours, its

great variety of hornbills, and its magnificent PhasianidÃ¦, comprising the

peacocks, argus-pheasants, fire-backed pheasants, and jungle-fowl. Many of

these are, it is true, absent from the peninsula of Hindostan, but

sufficient remain there to ally it with the other parts of the region.

Among the remarkable but less conspicuous forms of mammalia which are

peculiar to this region are, monkeys of the genus Presbyter, extending to

every part of it; lemurs of three peculiar genera--Nycticebus and Loris

(slow lemurs) and Tarsius (spectre lemurs); the flying lemur

(Galeopithecus), now classed as a peculiar family of Insectivora and found

only in the Malay Islands; the family of the Tupaias, or squirrel-shrews,

curious little arboreal Insectivora somewhat resembling squirrels; no less

than twelve peculiar genera of the civet family, three peculiar antelopes,

five species of rhinoceros, and the round-tailed flying squirrels forming

the genus Pteromys.

Of the peculiar groups of birds we can only mention a few. The curious

little tailor-birds of the genus Orthotomus are found over the whole region

and almost alone serve to characterise it, as do the fine

laughing-thrushes, forming the genus Garrulax; while the beautiful

grass-green fruit-thrushes (Phyllornis), and the brilliant little minivets

(Pericrocotus), are almost equally universal. Woodpeckers are abundant,

belonging to a dozen peculiar genera; while gaudy barbets and strange forms

of cuckoos and hornbills are also to be met with everywhere. Among game

birds, the only genus that is universally distributed, and which may be

said to characterise the region, is Gallus, comprising the true

jungle-fowl, one of which, Gallus bankiva, is found from the Himalayas and

Central India to Malacca, Java, and even eastward to Timor, and is the

undoubted origin of almost all our domestic poultry. Southern India and

Ceylon each possesses distinct species of jungle-fowl, and a third very

handsome green bird (Gallus Ã¦neus inhabits Java.)

Reptiles are as abundant as in Africa, but they present no well-known

groups which can be considered as specially characteristic. Among insects

we may notice the {46} magnificent golden and green PapilionidÃ¦ of various

genera as being unequalled in the world; while the great Atlas moth is

probably the most gigantic of Lepidoptera, being sometimes ten inches

across the wings, which are also very broad. Among the beetles the strange

flat-bodied Malayan mormolyce is the largest of all the CarabidÃ¦, while the

catoxantha is equally a giant among the BuprestidÃ¦. On the whole, the

insects of this region probably surpass those of any other part of the

world, except South America, in size, variety, and beauty.

\_Definition and Characteristic Groups of the Australian Region.\_--The

Australian region is so well marked off from the Oriental, as well as from

all other parts of the world, by zoological peculiarities, that we need not

take up much time in describing it, especially as some of its component

islands will come under review at a subsequent stage of our work. Its most

important portions are Australia and New Guinea, but it also includes all

the Malayan and Pacific Islands to the east of Borneo, Java, and Bali, the

Oriental region terminating with the submarine bank on which those islands

are situated. The island of Celebes is included in this region from a

balance of considerations, but it almost equally well belongs to the

Oriental, and must be left out of the account in our general sketch of the

zoological features of the Australian region.

The great feature of the Australian region is the almost total absence of

all the forms of terrestrial mammalia which abound in the rest of the

world, their place being supplied by a great variety of Marsupials. In

Australia and New Guinea there are no Insectivora, Carnivora, nor Ungulata,

while even the rodents are only represented by a few small rats and mice.

In the remoter Pacific Islands mammals are altogether absent (except

perhaps in New Zealand), but in the Moluccas and other islands bordering on

the Oriental region the higher mammals are represented by a few deer,

civets, and pigs, though it is doubtful whether the two former may not have

been introduced by man, as was almost certainly the case with the

semi-domesticated dingo of Australia.[8] These peculiarities in the

mammalia {47} are so great that every naturalist agrees that Australia must

be made a separate region, the only difference of opinion being as to its

extent, some thinking that New Zealand should form another separate region;

but this question need not now delay us.

In birds Australia is by no means so isolated from the rest of the world,

as it contains great numbers of warblers, thrushes, flycatchers, shrikes,

crows, and other familiar types of the Eastern Hemisphere; yet a

considerable number of the most characteristic Oriental families are

absent. Thus there are no vultures, woodpeckers, pheasants, bulbuls, or

barbets in the Australian region; and the absence of these is almost as

marked a feature as that of cats, deer, or monkeys, among mammalia. The

most conspicuous and characteristic birds of the Australian region are, the

piping crows; the honey-suckers (MeliphagidÃ¦), a family quite peculiar to

the region; the lyre-birds; the great terrestrial kingfishers (Dacelo); the

great goat-suckers called more-porks in Australia and forming the genus

Podargus; the wonderful abundance of parrots, including such remarkable

forms as the white and black cockatoos, and the gorgeously coloured

brush-tongued lories; the almost equal abundance of fine pigeons more gaily

coloured than any others on the globe; the strange brush-turkeys and

mound-builders, the only birds that {48} never sit upon their eggs, but

allow them to be hatched, reptile-like, by the heat of the sand or of

fermenting vegetable matter; and lastly, the emus and cassowaries, in which

the wings are far more rudimentary than in the ostriches of Africa and

South America. New Guinea and the surrounding islands are remarkable for

their tree-kangaroos, their birds-of-paradise, their raquet-tailed

kingfishers, their great crown-pigeons, their crimson lories, and many

other remarkable birds. This brief outline being sufficient to show the

distinctness and isolation of the Australian region, we will now pass to

the consideration of the Western Hemisphere.

\_Definition and Characteristic Groups of the Nearctic Region.\_--The

Nearctic region comprises all temperate and arctic North America, including

Greenland, the only doubt being as to its southern boundary, many northern

types penetrating into the tropical zone by means of the highlands and

volcanic peaks of Mexico and Guatemala, while a few which are

characteristic of the tropics extend northward into Texas and California.

There is, however, considerable evidence showing that on the east coast the

Rio Grande del Norte, and on the west a point nearly opposite Cape St.

Lucas, form the most natural boundary; but instead of being drawn straight

across, the line bends to the south-east as soon as it rises on the flanks

of the table-land, forming a deep loop which extends some distance beyond

the city of Mexico, and perhaps ought to be continued along the higher

ridges of Guatemala.

The Nearctic region is so similar to the PalÃ¦arctic in position and

climate, and the two so closely approach each other at Behring Straits,

that we cannot wonder at there being a certain amount of similarity between

them--a similarity which some naturalists have so far over-estimated as to

think that the two regions ought to be united. Let us therefore carefully

examine the special zoological features of this region, and see how far it

resembles, and how far differs from, the PalÃ¦arctic.

At first sight the mammalia of North America do not seem to differ much

from those of Europe or Northern Asia. There are cats, lynxes, wolves and

foxes, weasels, bears, elk and deer, voles, beavers, squirrels, marmots,

and {49} hares, all very similar to those of the Eastern Hemisphere, and

several hardly distinguishable. Even the bison or "buffalo" of the

prairies, once so abundant and characteristic, is a close ally of the now

almost extinct "aurochs" of Lithuania. Here, then, we undoubtedly find a

very close resemblance between the two regions, and if this were all, we

should have great difficulty in separating them. But along with these, we

find another set of mammals, not quite so conspicuous but nevertheless very

important. We have first, three peculiar genera of moles, one of which, the

star-nosed mole, is a most extraordinary creature, quite unlike anything

else. Then there are three genera of the weasel family, including the

well-known skunk (Mephitis), all quite different from Eastern forms. Then

we come to a peculiar family of carnivora, the racoons, very distinct from

anything in Europe or Asia; and in the Rocky Mountains we find the

prong-horn antelope (Antilocapra) and the mountain goat of the trappers

(Aplocerus), both peculiar genera. Coming to the rodents we find that the

mice of America differ in some dental peculiarities from those of the rest

of the world, and thus form several distinct genera; the jumping mouse

(Xapus) is a peculiar form of the jerboa family, and then we come to the

pouched rats (GeomyidÃ¦), a very curious family consisting of four genera

and nineteen species, peculiar to North America, though not confined to the

Nearctic region. The prairie dogs (Cynomys), the tree porcupine

(Erethizon), the curious sewellel (Haploodon), and the opossum (Didelphys)

complete the list of peculiar mammalia which distinguish the northern

region of the new world from that of the old. We must add to these

peculiarities some remarkable deficiencies. The Nearctic region has no

hedgehogs, nor wild pigs, nor dormice, and only one wild sheep in the Rocky

Mountains as against twenty species of sheep and goats in the PalÃ¦arctic

region.

In birds also the similarities to our own familiar songsters first strike

us, though the differences are perhaps really greater than in the

quadrupeds. We see thrushes and wrens, tits and finches, and what seem to

be warblers and flycatchers and starlings in abundance; but a closer

examination shows the ornithologist that what he took for the {50} latter

are really quite distinct, and that there is not a single true flycatcher

of the family MuscicapidÃ¦, or a single starling of the family SturnidÃ¦ in

the whole continent, while there are very few true warblers (SylviidÃ¦),

their place being taken by the quite distinct families MniotiltidÃ¦ or

wood-warblers, and VireonidÃ¦ or greenlets. In like manner the flycatchers

of America belong to the totally distinct family of tyrant-birds,

TyrannidÃ¦, and those that look like starlings to the hang-nests, IcteridÃ¦;

and these four peculiar families comprise about a hundred and twenty

species, and give a special character to the ornithology of the country.

Add to these such peculiar birds as the mocking thrushes (Mimus), the blue

jays (Cyanocitta), the tanagers, the peculiar genera of cuckoos (Coccygus

and Crotophaga), the humming-birds, the wild turkeys (Meleagris), and the

turkey-buzzards (Cathartes), and we see that if there is any doubt as to

the mammals of North America being sufficiently distinct to justify the

creation of a separate region, the evidence of the birds would alone settle

the question.

The reptiles, and some others of the lower animals, add still more to this

weight of evidence. The true rattlesnakes are highly characteristic, and

among the lizards are several genera of the peculiar American family, the

IguanidÃ¦. Nowhere in the world are the tailed batrachians so largely

developed as in this region, the Sirens and the AmphiumidÃ¦ forming two

peculiar families, while there are nine peculiar genera of salamanders, and

two others allied respectively to the Proteus of Europe and the Sieboldia

or giant salamander of Japan. There are seven peculiar families and about

thirty peculiar genera of fresh-water fishes; while the fresh-water

molluscs are more numerous than in any other region, more than thirteen

hundred species and varieties having been described.

Combining the evidence derived from all these classes of animals, we find

the Nearctic region to be exceedingly well characterised, and to be amply

distinct from the PalÃ¦arctic. The few species that are common to the two

are almost all arctic, or, at least, northern types, and may be compared

with those desert forms which occupy the debatable ground between the

PalÃ¦arctic, Ethiopian, and Oriental regions. {51} If, however, we compare

the number of species, which are common to the Nearctic and PalÃ¦arctic

regions with the number common to the western and eastern extremities of

the latter region, we shall find a wonderful difference between the two

cases; and if we further call to mind the number of important groups

characteristic of the one region but absent from the other, we shall be

obliged to admit that the relation that undoubtedly exists between the

faunas of North America and Europe is of a very distinct nature from that

which connects together Western Europe and North-eastern Asia in the bonds

of zoological unity.

\_Definition and Characteristic Groups of the Neotropical Region.\_--The

Neotropical region requires very little definition, since it comprises the

whole of America south of the Nearctic region, with the addition of the

Antilles or West Indian Islands. Its zoological peculiarities are almost as

marked as those of Australia, which, however, it far exceeds in the extreme

richness and variety of all its forms of life. To show how distinct it is

from all the other regions of the globe, we need only enumerate some of the

best known and more conspicuous of the animal forms which are peculiar to

it. Such are, among mammalia--the prehensile-tailed monkeys and the

marmosets, the blood-sucking bats, the coati-mundis, the peccaries, the

llamas and alpacas, the chinchillas, the agoutis, the sloths, the

armadillos, and the ant-eaters; a series of types more varied, and more

distinct from those of the rest of the world than any other continent can

boast of. Among birds we have the charming sugar-birds, forming the family

CoerebidÃ¦; the immense and wonderfully varied group of tanagers; the

exquisite little manakins, and the gorgeously-coloured chatterers; the host

of tree-creepers of the family DendrocolaptidÃ¦; the wonderful toucans; the

puff-birds, jacamars, todies and motmots; the marvellous assemblage of four

hundred distinct kinds of humming-birds; the gorgeous macaws; the

curassows, the trumpeters, and the sun-bitterns. Here again there is no

other continent or region that can produce such an assemblage of remarkable

and perfectly distinct groups of birds; and no less wonderful is its

richness in species, since these fully equal, if they do not surpass, those

of the {52} two great tropical regions of the Eastern Hemisphere (the

Ethiopian and the Oriental) combined.

As an additional indication of the distinctness and isolation of the

Neotropical region from all others, and especially from the whole Eastern

Hemisphere, we must say something of the otherwise widely distributed

groups which are absent. Among mammalia we have first the order

Insectivora, entirely absent from South America, though a few species are

found in Central America and the West Indies; the ViverridÃ¦ or civet family

is wholly wanting, as are every form of sheep, oxen, or antelopes; while

the swine, the elephants, and the rhinoceroses of the old world are

represented by the diminutive peccaries and tapirs.

Among birds we have to notice the absence of tits, true flycatchers,

shrikes, sunbirds, starlings, larks (except a solitary species in the

Andes), rollers, bee-eaters, and pheasants, while warblers are very scarce,

and the almost cosmopolitan wagtails are represented by a single species of

pipit.

We must also notice the preponderance of low or archaic types among the

animals of South America. Edentates, marsupials, and rodents form the

majority of the terrestrial mammalia; while such higher groups as the

carnivora and hoofed animals are exceedingly deficient. Among birds a low

type of Passeres, characterised by the absence of the singing muscles, is

excessively prevalent, the enormous groups of the ant-thrushes, tyrants,

tree-creepers, manakins, and chatterers belonging to it. The PicariÃ¦ (a

lower group) also prevail to a far greater extent than in any other

regions, both in variety of forms and number of species; and the chief

representatives of the gallinaceous birds--the curassows and tinamous, are

believed to be allied, the former to the brush-turkeys of Australia, the

latter (very remotely) to the ostriches, two of the least developed types

of birds.

Whether, therefore, we consider its richness in peculiar forms of animal

life, its enormous variety of species, its numerous deficiencies as

compared with other parts of the world, or the prevalence of a low type of

organisation among its higher animals, the Neotropical region stands out as

undoubtedly the most remarkable of the great zoological divisions of the

earth.

In reptiles, amphibia, fresh-water fishes, and insects, {53} this region is

equally peculiar, but we need not refer to these here, our only object now

being to establish by a sufficient number of well-known and easily

remembered examples, the distinctness of each region from all others, and

its unity as a whole. The former has now been sufficiently demonstrated,

but it may be well to say a few words as to the latter point.

The only outlying portions of the region about which there can be any doubt

are--Central America, or that part of the region north of the Isthmus of

Panama, the Antilles or West Indian Islands, and the temperate portion of

South America including Chili and Patagonia.

In Central America, and especially in Mexico, we have an intermixture of

South American and North American animals, but the former undoubtedly

predominate, and a large proportion of the peculiar Neotropical groups

extend as far as Costa Rica. Even in Guatemala and Mexico we have howling

and spider-monkeys, coati-mundis, tapirs, and armadillos; while chatterers,

manakins, ant-thrushes, and other peculiarly Neotropical groups of birds

are abundant. There is therefore no doubt as to Mexico forming part of this

region, although it is comparatively poor, and exhibits the intermingling

of temperate and tropical forms.

The West Indies are less clearly Neotropical, their poverty in mammals as

well as in most other groups being extreme, while great numbers of North

American birds migrate there in winter. The resident birds, however,

comprise trogons, sugar-birds, chatterers, with many humming-birds and

parrots, representing eighteen peculiar Neotropical genera; a fact which

decides the region to which the islands belong.

South temperate America is also very poor as compared with the tropical

parts of the region, and its insects contain a considerable proportion of

north temperate forms. But it contains armadillos, cavies and opossums; and

its birds all belong to American groups, though, owing to the inferior

climate and deficiency of forests, a number of the families of birds

peculiar to tropical America are wanting. Thus there are no manakins,

chatterers, toucans, trogons, or motmots; but there are abundance of

hang-nests, tyrant-birds, ant-thrushes, tree-creepers, and a fair {54}

proportion of humming-birds, tanagers and parrots. The zoology is therefore

thoroughly Neotropical, although somewhat poor; and it has a number of

peculiar forms of strictly Neotropical types--as the chinchillas, alpacas,

&c., which are not found in the tropical regions except in the high Andes.

\_Comparison of Zoological Regions with the Geographical Divisions of the

Globe.\_--Having now completed our survey of the great zoological regions of

the globe, we find that they do not differ so much from the old

geographical divisions as our first example might have led us to suppose.

Europe, Asia, Africa, Australia, North America, and South America, really

correspond, each to a zoological region, but their boundaries require to be

modified more or less considerably; and if we remember this, and keep their

extensions or limitations always in our mind, we may use the terms "South

American" or "North American," as being equivalent to Neotropical and

Nearctic, without much inconvenience, while "African" and "Australian"

equally well serve to express the zoological type of the Ethiopian and

Australian regions. Europe and Asia require more important modifications.

The European fauna does indeed well represent the PalÃ¦arctic in all its

main features, and if instead of Asia we say tropical Asia we have the

Oriental region very fairly defined; so that the relation of the

geographical with the zoological primary divisions of the earth is

sufficiently clear. In order to make these relations visible to the eye and

more easily remembered, we will put them into a tabular form:

Regions. Geographical Equivalent.

PalÃ¦arctic 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 N. America and W. Indies.

The following arrangement of the regions will indicate their geographical

position, and to a considerable extent their relation to each other.

N E A R C T I C--P A L Ã A R C T I C

| | |

| | ORIENTAL

| ETHIOPIAN |

NEO- |

TROPICAL AUSTRALIAN

May 4th. Diameter of spot 31Â° 24'

June 4th. ,, ,, 28Â° 0'

,, 17th. ,, ,, 22Â° 54'

July 4th. ,, ,, 18Â° 24'

,, 12th. ,, ,, 15Â° 20'

,, 20th. ,, ,, 18Â° 0'

We thus see that Mars has two permanent snow-caps, of nearly equal size in

winter but diminishing very unequally {55} in summer, when the southern cap

is reduced to nearly one third the size of the northern; and this fact is

held by Mr. Carpenter, as it was by the late Mr. Belt, to be opposed to the

view of the hemisphere which has winter in \_aphelion\_ (as the southern now

has both in the Earth and Mars), having been alone glaciated during periods

of high excentricity.[9]

Before, however, we can draw any conclusion from the case of Mars, we must

carefully scrutinise the facts, and the conditions they imply. In the first

place, there is evidently this radical difference between the state of Mars

now and of the Earth during a glacial period--that Mars has no great

ice-sheets spreading over its temperate zone, as the Earth undoubtedly had.

This we know from the fact of the \_rapid\_ disappearance of the white

patches over a belt three degrees wide in a fortnight (equal to a width of

about 100 miles of our measure), and in the northern hemisphere of eight

degrees wide (about 280 miles) between May 4th and July 12th. Even with our

much more powerful sun, which gives us more than twice as much heat as Mars

receives, no such diminution of an ice-sheet, or of glaciers of even

moderate thickness, could possibly occur; but the phenomenon is on the

contrary exactly analogous to what actually takes place on the plains of

Siberia in summer. These, as I am informed by Mr. Seebohm, are covered with

snow during winter and spring to a depth of six or eight feet, which

diminishes very little even under the hot suns of May, till warm winds

combine with the sun in June, when in about a fortnight the whole of it

disappears, and a little later the whole of northern Asia is free from its

winter covering. As, however, the sun of Mars is so much less powerful than

ours, we may be {56} sure that the snow (if it is real snow) is much less

thick--a mere surface-coating in fact, such as occurs in parts of Russia

where the precipitation is less, and the snow accordingly does not exceed

two or three feet in thickness.

We now see the reason why the \_southern\_ pole of Mars parts with its white

covering so much more quickly and to so much greater an extent than the

\_northern\_, for the south pole during summer is nearest the sun, and, owing

to the great excentricity of Mars, would have about one-third more heat

than during the summer of the northern hemisphere; and this greater heat

would cause the winds from the equator to be both warmer and more powerful,

and able to produce the same effects on the scanty Martian snows as they

produce on our northern snow-plains. The reason why both poles of Mars are

almost equally snow-covered in winter is not difficult to understand. Owing

to the greater obliquity of the ecliptic, and the much greater length of

the year, the polar regions will be subject to winter darkness fully twice

as long as with us, and the fact that one pole is nearer the sun during

this period than the other at a corresponding period, will therefore make

no perceptible difference. It is also probable that the two poles of Mars

are approximately alike as regards their geographical features, and that

neither of them is surrounded by very high land on which ice may

accumulate. With us at the present time, on the other hand, geographical

conditions completely mask and even reverse the influence of excentricity,

and that of winter in \_perihelion\_ in the northern, and summer in

\_perihelion\_ in the southern, hemisphere. In the north we have a

preponderance of sea within the Arctic circle, and of lowlands in the

temperate zone. In the south exactly opposite conditions prevail, for there

we have a preponderance of land (and much of it high land) within the

Antarctic circle, and of sea in the temperate zone. Ice, therefore,

accumulates in the south, while a thin coating of snow, easily melted in

summer, is the prevalent feature in the north; and these contrasts react

upon climate to such an extent, that in the southern ocean, islands in the

latitude of Ireland have glaciers descending to the level of the sea, and

constant snowstorms {57} in the height of summer, although the sun is then

actually nearer the earth than it is during our northern summer!

It is evident, therefore, that the phenomena presented by the varying polar

snows of Mars are in no way opposed to that modification of Dr. Croll's

theory of the conditions which brought about the glacial epochs of our

northern hemisphere, which is here advocated; but are perfectly explicable

on the same general principles, if we keep in mind the distinction between

an ice-sheet--which a summer's sun cannot materially diminish, but may even

increase by bringing vapour to be condensed into snow--and a thin snowy

covering which may be annually melted and annually renewed, with great

rapidity and over large areas. Except within the small circles of perpetual

polar snow there can at the present time be no ice-sheets in Mars; and the

reason why this permanent snowy area is more extensive around the northern

than around the southern pole may be partly due to higher land at the

north, but is perhaps sufficiently explained by the diminished power of the

summer sun, owing to its greatly increased distance at that season in the

northern hemisphere, so that it is not able to melt so much of the snow

which has accumulated during the long night of winter.

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CHAPTER IX

ANCIENT GLACIAL EPOCHS, AND MILD CLIMATES IN THE ARCTIC REGIONS

Dr. Croll's Views on Ancient Glacial Epochs--Effects of Denudation in

Destroying the Evidence of Remote Glacial Epochs--Rise of Sea-level

Connected with Glacial Epochs a Cause of Further Denudation--What

Evidence of Early Glacial Epochs may be Expected--Evidences of

Ice-action During the Tertiary Period--The Weight of the Negative

Evidence--Temperate Climates in the Arctic Regions--The Miocene Arctic

Flora--Mild Arctic Climates of the Cretaceous Period--Stratigraphical

Evidence of Long-continued Mild Arctic Conditions--The Causes of Mild

Arctic Climates--Geographical Conditions Favouring Mild Northern

Climates in Tertiary Times--The Indian Ocean as a Source of Heat in

Tertiary Times--Condition of North America During the Tertiary

Period--Effect of High Excentricity on Warm Polar Climates--Evidences

as to Climate in the Secondary and PalÃ¦ozoic Epochs--Warm Arctic

Climates in Early Secondary and PalÃ¦ozoic Times--Conclusions as to the

Climates of Secondary and Tertiary Periods--General View of Geological

Climates as Dependent on the Physical Features of the Earth's

Surface--Estimate of the Comparative Effects of Geographical and

Physical Causes in Producing Changes of Climate.

If we adopt the view set forth in the preceding chapter as to the character

of the glacial epoch and of the accompanying alternations of climate, it

must have been a very important agent in producing changes in the

distribution of animal and vegetable life. The intervening mild periods,

which almost certainly occurred during its earlier and later phases, may

have been sometimes more equable than even our present insular climate, and

severe frosts were probably then unknown. During the four or five {59}

thousand years that each specially mild period may have lasted, some

portions of the north temperate zone, which had been buried in snow or ice,

would become again clothed with vegetation and stocked with animal life,

both of which, as the cold again came on, would be driven southward, or

perhaps partially exterminated. Forms usually separated would thus be

crowded together, and a struggle for existence would follow, which must

have led to the modification or the extinction of many species. When the

survivors in the struggle had reached a state of equilibrium, a fresh field

would be opened to them by the later ameliorations of climate; the more

successful of the survivors would spread and multiply; and after this had

gone on for thousands of generations, another change of climate, another

southward migration, another struggle of northern and southern forms would

take place.

But if the last glacial epoch has coincided with, and has been to a

considerable extent caused by, a high excentricity of the earth's orbit, we

are naturally led to expect that earlier glacial epochs would have occurred

whenever the excentricity was unusually large. Dr. Croll has published

tables showing the varying amounts of excentricity for three million years

back; and from these it appears that there have been many periods of high

excentricity, which has often been far greater than at the time of the last

glacial epoch.[10] The accompanying diagram has been drawn from these

tables, and it will be seen that the highest excentricity occurred 850,000

years ago, at which time the difference between the sun's distance at

\_aphelion\_ and \_perihelion\_ was thirteen and a half millions of miles,

whereas during the last glacial period the maximum difference was ten and a

half million miles.

[Illustration: DIAGRAM SHOWING THE CHANGES OF EXCENTRICITY DURING THE LAST

THREE MILLION YEARS.]

Now, judging by the amount of organic and physical change that occurred

during and since the glacial epoch, and that which has occurred since the

Miocene period, it is considered probable that this maximum of excentricity

coincided with some part of the latter period; and Dr. Croll maintains that

a glacial epoch must then have {60} occurred surpassing in severity that of

which we have such convincing proofs, and consisting like it of

alternations of cold and warm phases every 10,500 years. The diagram also

shows us another long-continued period of high excentricity from 1,750,000

to 1,950,000 years ago, and yet another almost equal to the maximum

2,500,000 years back. These may perhaps have occurred during the Eocene and

Cretaceous epochs respectively, or all may have been included within the

limits of the Tertiary period. As two of these high excentricities greatly

exceed that which caused our glacial epoch, while the third is almost equal

to it and of longer duration, they seem to afford us the means of testing

rival theories of the causes of glaciation. If, as Dr. Croll argues, high

excentricity is the great and dominating agency in bringing on glacial

epochs, geographical changes being subordinate, then there must have been

glacial epochs of great severity at all these three periods; while if he is

also correct in supposing that the alternate phases of precession would

inevitably produce glaciation in one hemisphere, and a proportionately mild

and equable climate in the opposite hemisphere, then we should have to look

for evidence of exceptionally warm and exceptionally cold periods,

occurring {61} alternately and with several repetitions, within a space of

time which, geologically speaking, is very short indeed.

Let us then inquire first into the character of the evidence we should

expect to find of such changes of climate, if they have occurred; we shall

then be in a better position to estimate at its proper value the evidence

that actually exists, and, after giving it due weight, to arrive at some

conclusion as to the theory that best explains and harmonises it.

\_Effects of Denudation in Destroying the Evidence of Remote Glacial

Epochs.\_--It may be supposed, that if earlier glacial epochs than the last

did really occur, we ought to meet with some evidence of the fact

corresponding to that which has satisfied us of the extensive recent

glaciation of the northern hemisphere; but Dr. Croll and other writers have

ably argued that no such evidence is likely to be found. It is now

generally admitted that sub-aÃ«rial denudation is a much more powerful agent

in lowering and modifying the surface of a country than was formerly

supposed. It has in fact been proved to be so powerful that the difficulty

now felt is, not to account for the denudation which can be proved to have

occurred, but to explain the apparent persistence of superficial features

which ought long ago to have been destroyed.

A proof of the lowering and eating away of the land-surface which every one

can understand, is to be found in the quantity of solid matter carried down

to the sea and to low grounds by rivers. This is capable of pretty accurate

measurement, and it has been carefully measured for several rivers, large

and small, in different parts of the world. The details of these

measurements will be given in a future chapter, and it is only necessary

here to state that the average of them all gives us this result--that one

foot must, on an average, be taken off the entire surface of the land each

3,000 years in order to produce the amount of sediment and matter in

solution which is actually carried into the sea. To give an idea of the

limits of variation in different rivers it may be mentioned that the

Mississippi is one which denudes its valley at a slow rate, taking 6,000

{62} years to remove one foot; while the Po is the most rapid, taking only

729 years to do the same work in its valley. The cause of this difference

is very easy to understand. A large part of the area of the Mississippi

basin consists of the almost rainless prairie and desert regions of the

west, while its sources are in comparatively arid mountains with scanty

snow-fields, or in a low forest-clad plateau. The Po, on the other hand, is

wholly in a district of abundant rainfall, while its sources are spread

over a great amphitheatre of snowy Alps nearly 400 miles in extent, where

the denuding forces are at a maximum. As Scotland is a mountain region of

rather abundant rainfall, the denuding power of its rains and rivers is

probably rather above than under the average, but to avoid any possible

exaggeration we will take it at a foot in 4,000 years.

Now if the end of the glacial epoch be taken to coincide with the

termination of the last period of high excentricity, which occurred about

80,000 years ago (and no geologist will consider this too long for the

changes which have since taken place), it follows that the entire surface

of Scotland must have been since lowered an average amount of twenty feet.

But over large areas of alluvial plains, and wherever the rivers have

spread during floods, the ground will have been raised instead of lowered;

and on all nearly level ground and gentle slopes there will have been

comparatively little denudation; so that proportionally much more must have

been taken away from mountain sides and from the bottoms of valleys having

a considerable downward slope. One of the very highest authorities on the

subject of denudation, Mr. Archibald Geikie, estimates the area of these

more rapidly denuded portions as only one-tenth of the comparatively level

grounds, and he further estimates that the former will be denuded about ten

times as fast as the latter. It follows that the valleys will be deepened

and widened on the average about five feet in the 4,000 years instead of

one foot; and thus many valleys must have been deepened and widened 100

feet, and some even more, since the glacial epoch, while the more level

portions of the country will have been lowered on the average only about

two feet. {63}

Now Dr. Croll gives us the following account of the present aspect of the

surface of a large part of the country:--

"Go where one will in the lowlands of Scotland and he shall hardly find a

single acre whose upper surface bears the marks of being formed by the

denuding agents now in operation. He will observe everywhere mounds and

hollows which cannot be accounted for by the present agencies at work....

In regard to the general surface of the country the present agencies may be

said to be just beginning to carve a new line of features out of the old

glacially-formed surface. But so little progress has yet been made, that

the kames, gravel-mounds, knolls of boulder clay, &c., still retain in most

cases their original form."[11]

The facts here seem a little inconsistent, and we must suppose that Dr.

Croll has somewhat exaggerated the universality and complete preservation

of the glaciated surface. The amount of average denudation, however, is not

a matter of opinion but of measurement; and its consequences can in no way

be evaded. They are, moreover, strictly proportionate to the time elapsed;

and if so much of the old surface of the country has certainly been

remodelled or carried into the sea since the last glacial epoch, it becomes

evident that any surface-phenomena produced by still earlier glacial epochs

\_must\_ have long since entirely disappeared.

\_Rise of the Sea-level Connected with Glacial Epochs, a Cause of Further

Denudation.\_--There is also another powerful agent that must have assisted

in the destruction of any such surface deposits or markings. During the

last glacial epoch itself there were several minor oscillations of the

land, without counting the great submergence of over 1,300 feet, supposed

to be indicated by patches of shelly clays and gravels in Wales and

Ireland, and also in a few localities in England and Scotland, since these

are otherwise explained by many geologists. Other subsidences have no doubt

occurred in the same areas during the Tertiary epoch, and some writers

connect these subsidences with the glacial {64} period itself, the unequal

amount of ice at the two poles causing the centre of gravity of the earth

to be displaced when, of course, the surface of the ocean will conform to

it and appear to rise in the one hemisphere and sink in the other. If this

is the case, subsidences of the land are natural concomitants of a glacial

period, and will powerfully aid in removing all evidence of its occurrence.

We have seen reason to believe, however, that during the height of the

glacial epoch the extreme cold persisted through the successive phases of

precession, and if so, both polar areas would probably be glaciated at

once. This would cause the abstraction of a large quantity of water from

the ocean, and a proportionate elevation of the land, which would react on

the accumulation of snow and ice, and thus add another to that wonderful

series of physical agents which act and react on each other so as to

intensify glacial epochs.

But whether or not these causes would produce any important fluctuations of

the sea-level is of comparatively little importance to our present inquiry,

because the wide extent of marine Tertiary deposits in the northern

hemisphere and their occurrence at considerable elevations above the

present sea-level, afford the most conclusive proofs that great changes of

sea and land have occurred throughout the entire Tertiary period; and these

repeated submergences and emergences of the land combined with sub-aÃ«rial

and marine denudation, would undoubtedly destroy all those superficial

evidences of ice-action on which we mainly depend for proofs of the

occurrence of the last glacial epoch.

\_What Evidence of Early Glacial Epochs may be Expected.\_--Although we may

admit the force of the preceding argument as to the extreme improbability

of our finding any clear evidence of the superficial action of ice during

remote glacial epochs, there is nevertheless one kind of evidence that we

ought to find, because it is both wide-spread and practically

indestructible.

One of the most constant of all the phenomena of a glaciated country is the

abundance of icebergs produced by the breaking off of the ends of glaciers

which terminate {65} in arms of the sea, or of the terminal face of the

ice-sheet which passes beyond the land into the ocean. In both these cases

abundance of rocks and \_dÃ©bris\_, such as form the terminal moraines of

glaciers on land, are carried out to sea and deposited over the sea-bottom

of the area occupied by icebergs. In the case of an ice-sheet it is almost

certain that much of the ground-moraine, consisting of mud and imbedded

stones, similar to that which forms the "till" when deposited on land, will

be carried out to sea with the ice and form a deposit of marine "till" near

the shore.

It has indeed been objected that when an ice-sheet covered an entire

country there would be no moraines, and that rocks or \_dÃ©bris\_ are very

rarely seen on icebergs. But during every glacial epoch there will be a

southern limit to the glaciated area, and everywhere near this limit the

mountain-tops will rise far above the ice and deposit on it great masses of

\_dÃ©bris\_; and as the ice-sheet spreads, and again as it passes away, this

moraine-forming area will successively occupy the whole country. But even

such an ice-clad country as Greenland is now known to have protruding peaks

and rocky masses which give rise to moraines on its surface;[12] and, as

rocks from Cumberland and Ireland were carried by the ice-sheet to the Isle

of Man, there must have been a very long period during which the ice-sheets

of Britain and Ireland terminated in the ocean and sent off abundance of

rock-laden bergs into the surrounding seas; and the same thing must have

occurred along all the coasts of Northern Europe and Eastern America.

We cannot therefore doubt that throughout the greater part of the duration

of a glacial epoch the seas adjacent to the glaciated countries would

receive continual deposits of large rocks, rock-fragments, and gravel,

similar to the material of modern and ancient moraines, and analogous to

the drift and the numerous travelled blocks which the ice has undoubtedly

scattered broadcast over every glaciated country; and these rocks and

boulders would be imbedded in whatever deposits were then forming, either

from the matter carried down by rivers or from the mud ground off {66} the

rocks and carried out to sea by the glaciers themselves. Moreover, as

icebergs float far beyond the limits of the countries which gave them

birth, these ice-borne materials would be largely imbedded in deposits

forming from the denudation of countries which had never been glaciated, or

from which the ice had already disappeared.

But if every period of high excentricity produced a glacial epoch of

greater or less extent and severity, then, on account of the frequent

occurrence of a high phase of excentricity during the three million years

for which we have the tables, these boulder and rock-strewn deposits would

be both numerous and extensive. Four hundred thousand years ago the

excentricity was almost exactly the same as it is now, and it continually

increased from that time up to the glacial epoch. Now if we take double the

present excentricity as being sufficient to produce some glaciation in the

temperate zone, we find (by drawing out the diagram at p. 171 on a larger

scale) that during 1,150,000 years out of the 2,400,000 years immediately

preceding the last glacial epoch, the excentricity reached or exceeded this

amount, consisting of sixteen separate epochs, divided from each other by

periods varying from 30,000 to 200,000 years. But if the last glacial epoch

was at its maximum 200,000 years ago, a space of three million years will

certainly include much, if not all, of the Tertiary period; and even if it

does not, we have no reason to suppose that the character of the

excentricity would suddenly change beyond the three million years.

It follows, therefore, that if periods of high excentricity, like that

which appears to have been synchronous with our last glacial epoch and is

generally admitted to have been one of its efficient causes, always

produced glacial epochs (with or without alternating warm periods), then

the whole of the Tertiary deposits in the north temperate and Arctic zones

should exhibit frequent alternations of boulder and rock-bearing beds, or

coarse rock-strewn gravels analogous to our existing glacial drift, and

with some corresponding change of organic remains. Let us then see what

evidence can be adduced of the existence of such deposits, and whether it

is adequate to support the {67} theory of repeated glacial epochs during

the Tertiary period.

\_Evidences of Ice-action during the Tertiary Period.\_--The Tertiary fossils

both of Europe and North America indicate throughout warm or temperate

climates, except those of the more recent Pliocene deposits which merge

into the earlier glacial beds. The Miocene deposits of Central and Southern

Europe, for example, contain marine shells of some genera now only found

farther south, while the fossil plants often resemble those of Madeira and

the southern states of North America. Large reptiles, too, abounded, and

man-like apes lived in the south of France and in Germany. Yet in Northern

Italy, near Turin, there are beds of sandstone and conglomerate full of

characteristic Miocene shells, but containing in an intercalated deposit

angular blocks of serpentine and greenstone often of enormous size, one

being fourteen feet long, and another twenty-six feet. Some of the blocks

were observed by Sir Charles Lyell to be faintly striated and partly

polished on one side, and they are scattered through the beds for a

thickness of nearly 150 feet. It is interesting that the particular bed in

which the blocks occur yields no organic remains, though these are

plentiful both in the underlying and overlying beds, as if the cold of the

icebergs, combined with the turbidity produced by the glacial mud, had

driven away the organisms adapted to live only in a comparatively warm sea.

Rock similar in kind to these erratics occurs about twenty miles distant in

the Alps.

The Eocene period is even more characteristically tropical in its flora and

fauna, since palms and CycadaceÃ¦, turtles, snakes, and crocodiles then

inhabited England. Yet on the north side of the Alps, extending from

Switzerland to Vienna, and also south of the Alps near Genoa, there is a

deposit of finely-stratified sandstone several thousand feet in thickness,

quite destitute of organic remains, but containing in several places in

Switzerland enormous blocks either angular or partly rounded, and composed

of oolitic limestone or of granite. Near the Lake of Thun some of the

granite blocks found in this deposit are of enormous size, one of them

being 105 feet long, ninety feet wide, {68} and forty-five feet thick! The

granite is red, and of a peculiar kind which cannot be matched anywhere in

the Alps, or indeed elsewhere. Similar erratics have also been found in

beds of the same age in the Carpathians and in the Apennines, indicating

probably an extensive inland European sea into which glaciers descended

from the surrounding mountains, depositing these erratics, and cooling the

water so as to destroy the mollusca and other organisms which had

previously inhabited it. It is to be observed that wherever these erratics

occur they are always in the vicinity of great mountain ranges; and

although these can be proved to have been in great part elevated during the

Tertiary period, we must also remember that they must have been since very

much lowered by denudation, of the amount of which, the enormously thick

Eocene and Miocene beds now forming portions of them is in some degree a

measure as well as a proof. It is not therefore at all improbable that

during some part of the Tertiary period these mountains may have been far

higher than they are now, and this we know might be sufficient for the

production of glaciers descending to the sea-level, even were the climate

of the lowlands somewhat warmer than at present.[13]

\_The Weight of the Negative Evidence.\_--But when we proceed to examine the

Tertiary deposits of other parts of {69} Europe, and especially of our own

country, for evidence of this kind, not only is such evidence completely

wanting, but the facts are of so definite a character as to satisfy most

geologists that it can never have existed; and the same maybe said of

temperate North America and of the Arctic regions generally.

In his carefully written paper on "The Climate Controversy" the late Mr.

Searles V. Wood, Jun., remarks on this point as follows: "Now the Eocene

formation is complete in England, and is exposed in continuous section

along the north coast of the Isle of Wight from its base to its junction

with the Oligocene (or Lower Miocene according to some), and along the

northern coast of Kent from its base to the Lower Bagshot Sand. It has been

intersected by railway and other cuttings in all directions and at all

horizons, and pierced by wells innumerable; while from its strata in

England, France, and Belgium, the most extensive collections of organic

remains have been made of any formation yet explored, and from nearly all

its horizons, for at one place or another in these three countries nearly

every horizon may be said to have yielded fossils of some kind. These

fossils, however, whether they be the remains of a flora such as that of

Sheppey, or of a vertebrate fauna containing the crocodile and alligator,

such as is yielded by beds indicative of terrestrial conditions, or of a

molluscan assemblage such as is present in marine or fluvio-marine beds of

the formation, are of unmistakably tropical or sub-tropical character

throughout; and no trace whatever has appeared of the intercalation of a

glacial period, much less of successive intercalations indicative of more

than one period of 10,500 years' glaciation. Nor can it be urged that the

glacial epochs of the Eocene in England were intervals of dry land, and so

have left no evidence of their existence behind them, because a large part

of the continuous sequence of Eocene deposits in this country consists of

alternations of fluviatile, fluvio-marine, and purely marine strata; so

that it seems impossible that during the accumulation of the Eocene

formation in England a glacial period could have occurred without its

evidences being {70} abundantly apparent. The Oligocene of Northern Germany

and Belgium, and the Miocene of those countries and of France, have also

afforded a rich molluscan fauna, which, like that of the Eocene, has as yet

presented no indication of the intrusion of anything to interfere with its

uniformly sub-tropical character."[14]

This is sufficiently striking; but when we consider that this enormous

series of deposits, many thousand feet in thickness, consists wholly of

alternations of clays, sands, marls, shales, or limestones, with a few beds

of pebbles or conglomerate, not one of the whole series containing

irregular blocks of foreign material, boulders or gravel, such as we have

seen to be the essential characteristic of a glacial epoch; and when we

find that this same general character pervades all the extensive Tertiary

deposits of temperate North America, we shall, I think, be forced to the

conclusion that no general glacial epochs could have occurred during their

formation. It must be remembered that the "imperfection of the geological

record" will not help us here, because the series of Tertiary deposits is

unusually complete, and we must suppose some destructive agency to have

selected all the intercalated glacial beds and to have so completely made

away with them that not a fragment remains, while preserving all or almost

all the \_interglacial\_ beds; and to have acted thus capriciously, not in

one limited area only, but over the whole northern hemisphere, with the

local exceptions on the flanks of great mountain ranges already referred

to.

\_Temperate Climates in the Arctic Regions.\_--As we have just seen, the

geological evidence of the persistence of sub-tropical or warm climates in

the north temperate zone during the greater part of the Tertiary period is

almost irresistible, and we have now to consider the still more

extraordinary series of observations which demonstrate that this

amelioration of climate extended into the Arctic zone, and into countries

now almost wholly buried in snow and ice. These warm Arctic climates have

been explained by Dr. Croll as due to periods of high excentricity with

winter in \_perihelion\_, a theory which implies alternating {71} epochs of

glaciation far exceeding what now prevails; and it is therefore necessary

to examine the evidence pretty closely in order to see if this view is more

tenable in the case of the north polar regions than we have found it to be

in that of the north temperate zone.

The most recent of these milder climates is perhaps indicated by the

abundant remains of large mammalia--such as the mammoth, woolly rhinoceros,

bison and horse, in the icy alluvial plains of Northern Siberia, and

especially in the Liakhov Islands in the same latitude as the North Cape of

Asia. These remains occur not in one or two spots only, as if collected by

eddies at the mouth of a river, but along the whole borders of the Arctic

Ocean; and it is generally admitted that the animals must have lived upon

the adjacent plains, and that a considerably milder climate than now

prevails could alone have enabled them to do so. How long ago this occurred

we do not know, but one of the last intercalated mild periods of the

glacial epoch itself seems to offer all the necessary conditions. Again,

Sir Edward Belcher discovered on the dreary shores of Wellington Channel in

75Â½Â° N. Lat. the trunk and root of a fir tree which had evidently grown

where it was found. It appeared to belong to the species \_Abies alba\_, or

white fir, which now reaches 68Â° N. Lat. and is the most northerly conifer

known. Similar trees, one four feet in circumference and thirty feet long,

were found by Lieut. Mecham in Prince Patrick's Island in Lat. 76Â° 12' N.,

and other Arctic explorers have found remains of trees in high

latitudes.[15]

Similar indications of a recent milder climate are found in Spitzbergen.

Professor NordenskjÃ¶ld says: "At various places on Spitzbergen, at the

bottom of Lomme Bay, at Cape Thordsen, in Blomstrand's strata in Advent

Bay, there are found large and well-developed shells of a bivalve, \_Mytilus

edulis\_, which is not now found living on the coast of Spitzbergen, though

on the west coast of Scandinavia it everywhere covers the rocks near the

sea-shore. These shells occur most plentifully in the bed of a river which

runs through Reindeer Valley at Cape Thordsen. They {72} are probably

washed out of a thin bed of sand at a height of about twenty or thirty feet

above the present sea-level, which is intersected by the river. The

geological age of this bed cannot be very great, and it has clearly been

formed since the present basin of the Ice Sound, or at least the greater

part of it, has been hollowed out by glacial action."[16]

\_The Miocene Arctic Flora.\_--One of the most startling and important of the

scientific discoveries of the last forty years has been that of the relics

of a luxuriant Miocene flora in various parts of the Arctic regions. It is

a discovery that was totally unexpected, and is even now considered by many

men of science to be completely unintelligible; but it is so thoroughly

established, and it has such a direct and important bearing on the subjects

we are discussing in the present volume, that it is necessary to lay a

tolerably complete outline of the facts before our readers.

The Miocene flora of temperate Europe was very like that of Eastern Asia,

Japan, and the warmer part of Eastern North America of the present day. It

is very richly represented in Switzerland by well preserved fossil remains,

and after a close comparison with the flora of other countries Professor

Heer concludes that the Swiss Lower Miocene flora indicates a climate

corresponding to that of Louisiana, North Africa, and South China, while

the Upper Miocene climate of the same country would correspond to that of

the south of Spain, Southern Japan, and Georgia (U.S. of America). Of this

latter flora, found chiefly at Oeninghen in the northern extremity of

Switzerland, 465 species are known, of which 166 species are trees or

shrubs, half of them being evergreens. They comprise sequoias like the

Californian giant trees, camphor-trees, cinnamons, sassafras, bignonias,

cassias, gleditschias, tulip-trees, and many other American genera,

together with maples, ashes, planes, oaks, poplars, and other familiar

European trees represented by a variety of extinct species. If we now go to

the west coast of Greenland in 70Â° N. Lat. we find abundant remains of a

flora of the same general {73} type as that of Oeninghen but of a more

northern character. We have a sequoia identical with one of the species

found at Oeninghen, a chestnut, salisburia, liquidambar, sassafras, and

even a magnolia. We have also seven species of oaks, two planes, two vines,

three beeches, four poplars, two willows, a walnut, a plum, and several

shrubs supposed to be evergreens; altogether 137 species, mostly well and

abundantly preserved!

But even further north, in Spitzbergen, in 78Â° and 79Â° N. Lat. and one of

the most barren and inhospitable regions on the globe, an almost equally

rich fossil flora has been discovered including several of the Greenland

species, and others peculiar, but mostly of the same genera. There seem to

be no evergreens here except coniferÃ¦, one of which is identical with the

swamp-cypress (\_Taxodium distichum\_) now found living in the Southern

United States! There are also eleven pines, two Libocedrus, two sequoias,

with oaks, poplars, birches, planes, limes, a hazel, an ash, and a walnut;

also water-lilies, pond-weeds, and an iris--altogether about a hundred

species of flowering plants. Even in Grinnell Land, within 8Â¼ degrees of

the pole, a similar flora existed, twenty-five species of fossil plants

having been collected by the last Arctic expedition, of which eighteen were

identical with the species from other Arctic localities. This flora

comprised poplars, birches, hazels, elms, viburnums, and eight species of

conifers including the swamp cypress and the Norway spruce (\_Pinus abies\_)

which last does not now extend beyond 69Â½Â° N.

Fossil plants closely resembling those just mentioned have been found at

many other Arctic localities, especially in Iceland, on the Mackenzie River

in 65Â° N. Lat. and in Alaska. As an intermediate station we have, in the

neighbourhood of Dantzic in Lat. 55Â° N., a similar flora, with the

swamp-cypress, sequoias, oaks, poplars, and some cinnamons, laurels, and

figs. A little further south, near Breslau, north of the Carpathians, a

rich flora has been found allied to that of Oeninghen, but wanting in some

of the more tropical forms. Again, in the Isle of Mull in Scotland, in

about 56Â½Â° N. Lat., a plant-bed has been discovered {74} containing a

hazel, a plane, and a sequoia, apparently identical with a Swiss Miocene

species.

We thus find one well-marked type of vegetation spread from Switzerland and

Vienna to North Germany, Scotland, Iceland, Greenland, Alaska, and

Spitzbergen, some few of the species even ranging over the extremes of

latitude between Oeninghen and Spitzbergen, but the great majority being

distinct, and exhibiting decided indications of a decrease of temperature

according to latitude, though much less in amount than now exists. Some

writers have thought that the great similarity of the floras of Greenland

and Oeninghen is a proof that they were not contemporaneous, but

successive; and that of Greenland has been supposed to be as old as the

Eocene. But the arguments yet adduced do not seem to prove such a

difference of age, because there is only that amount of specific and

generic diversity between the two which might be produced by distance and

difference of temperature, under the exceptionally equable climate of the

period. We have even now examples of an equally wide range of well-marked

types; as in temperate South America, where many of the genera and some of

the species range from the Straits of Magellan to Valparaiso--places

differing as much in latitude as Switzerland and West Greenland; and the

same may be said of North Australia and Tasmania, where, at a greater

latitudinal distance apart, closely allied forms of Eucalyptus, Acacia,

Casuarina, Stylidium, Goodenia, and many other genera would certainly form

a prominent feature in any fossil flora now being preserved.

\_Mild Arctic Climates of the Cretaceous Period.\_--In the Upper Cretaceous

deposits of Greenland (in a locality not far from those of the Miocene age

last described) another remarkable flora has been discovered, agreeing

generally with that of Europe and North America of the same geological age.

Sixty-five species of plants have been identified, of which there are

fifteen ferns, two cycads, eleven coniferÃ¦, three monocotyledons, and

thirty-four dicotyledons. One of the ferns is a tree-fern with thick stems,

which has also been found in the Upper Greensand of England. Among the

conifers the giant sequoias are found, and among {75} the dicotyledons the

genera Populus, Myrica, Ficus, Sassafras, Andromeda, Diospyros, Myrsine,

Panax, as well as magnolias, myrtles, and leguminosÃ¦. Several of these

groups occur also in the much richer deposits of the same age in North

America and Central Europe; but all of them evidently afford such

fragmentary records of the actual flora of the period, that it is

impossible to say that any genus found in one locality was absent from the

other merely because it has not yet been found there. On the whole, there

seems to be less difference between the floras of Arctic and temperate

latitudes in Upper Cretaceous than in Miocene times.

In the same locality in Greenland (70Â° 33' N. Lat. and 52Â° W. Long.), and

also in Spitzbergen, a more ancient flora, of Lower Cretaceous age, has

been found; but it differs widely from the other in the great abundance of

cycads and conifers and the scarcity of exogens, which latter are

represented by a single poplar. Of the thirty-eight ferns, fifteen belong

to the genus Gleichenia now almost entirely tropical. There are four genera

of cycads, and three extinct genera of conifers, besides Glyptostrobus and

Torreya now found only in China and California, six species of true pines,

and five of the genus Sequoia, one of which occurs also in Spitzbergen. The

European deposits of the same age closely agree with these in their general

character, conifers, cycads, and ferns forming the mass of the vegetation,

while exogens are entirely absent, the above-named Greenland poplar being

the oldest known dicotyledonous plant.[17]

If we take these facts as really representing the flora of the period, we

shall be forced to conclude that, measured by the change effected in its

plants, the lapse of time between the Lower and Upper Cretaceous deposits

was far greater than between the Upper Cretaceous and the Miocene--a

conclusion quite opposed to the indications afforded by the mollusca and

the higher animals of the two periods. It seems probable, therefore, that

these Lower Cretaceous plants represent local peculiarities of {76}

vegetation such as now sometimes occur in tropical countries. On sandy or

coralline islands in the Malay Archipelago there will often be found a

vegetation consisting almost wholly of cycads, pandani, and palms, while a

few miles off, on moderately elevated land, not a single specimen of either

of these families may be seen, but a dense forest of dicotyledonous trees

covering the whole country. A lowland vegetation, such as that above

described, might be destroyed and its remains preserved by a slight

depression, allowing it to be covered up by the detritus of some adjacent

river, while not only would the subsidence of high land be a less frequent

occurrence, but when it did occur the steep banks would be undermined by

the waves, and the trees falling down would be floated away, and would

either be cast on some distant shore or slowly decay on the surface or in

the depths of the ocean.

From the remarkable series of facts now briefly summarized, we learn, that

whenever plant-remains have been discovered within the Arctic regions,

either in Tertiary or Cretaceous deposits, they show that the climate was

one capable of supporting a rich vegetation of trees, shrubs, and

herbaceous plants, similar in general character to that which prevailed in

the temperate zone at the same periods, but showing the influence of a less

congenial climate. These deposits belong to at least four distinct

geological horizons, and have been found widely scattered within the Arctic

circle, yet nowhere has any proof been obtained of intercalated cold

periods, such as would be indicated by the remains of a stunted vegetation,

or a molluscan fauna similar to that which now prevails there.

\_Stratigraphical Evidence of Long-Continued Mild Arctic Conditions.\_--Let

us now turn to the stratigraphical evidence, which, as we have already

shown, offers a crucial test of the occurrence or non-occurrence of

glaciation during any extensive geological period; and here we have the

testimony of perhaps the greatest living authority on Arctic

geology--Professor NordenskjÃ¶ld. In his lecture on "The Former Climate of

the Polar Regions," he says: "The character of the coasts in the Arctic

regions is especially favourable to geological investigations. While the

valleys are for the {77} most part filled with ice, the sides of the

mountains in summer, even in the 80th degree of latitude, and to a height

of 1,000 or 1,500 feet above the level of the sea, are almost wholly free

from snow. Nor are the rocks covered with any amount of vegetation worth

mentioning; and, moreover, the sides of the mountains on the shore itself

frequently present perpendicular sections, which everywhere expose their

bare surfaces to the investigator. The knowledge of a mountain's geognostic

character, at which one, in the more southerly countries, can only arrive

after long and laborious researches, removal of soil and the like, is here

gained almost at the first glance; and as we have never seen in Spitzbergen

nor in Greenland, in these sections often many miles in length, and

including one may say all formations from the Silurian to the Tertiary, any

boulders even as large as a child's head, there is not the smallest

probability that strata of any considerable extent, containing boulders,

are to be found in the polar tracts previous to the middle of the Tertiary

period. Since, then, both an examination of the geognostic condition, and

an investigation of the fossil flora and fauna of the polar lands, show no

signs of a glacial era having existed in those parts before the termination

of the Miocene period, we are fully justified in rejecting, on the evidence

of actual observation, the hypotheses founded on purely theoretical

speculations, which assume the many times repeated alternation of warm and

glacial climates between the present time and the earliest geological

ages."[18] And again, in his \_Sketch of the Geology of Spitzbergen\_, after

describing the various formations down to the Miocene, he says: "All the

fossils found in the foregoing strata show that Spitzbergen, during former

geological ages, enjoyed a magnificent climate, which indeed was somewhat

colder during the Miocene period, but was still favourable for an

extraordinarily abundant vegetation, much more luxuriant than that which

now occurs even in the southern part of Scandinavia: and I have in those

strata sought in vain for any sign, that, as some geologists have of late

endeavoured to render probable, these favourable climatic conditions have

been broken off {78} by intervals of ancient glacial periods. The profiles

I have had the opportunity to examine during my various Spitzbergen

expeditions would certainly, if laid down on a line, occupy an extent of \_a

thousand English miles\_; and if any former glacial period had existed in

this region, there ought to have been some trace to be observed of erratic

blocks, or other formations which distinguish glacial action. But this has

not been the case. In the strata, whose length I have reckoned alone, I

have not found a single fragment of a foreign rock so large as a child's

head."[19]

Now it is quite impossible to ignore or evade the force of this testimony

as to the continuous warm climates of the north temperate and polar zones

throughout Tertiary times. The evidence extends over a vast area, both in

space and time, it is derived from the work of the most competent living

geologists, and it is absolutely consistent in its general tendency. We

have in the Lower Cretaceous period an almost tropical climate in France

and England, a somewhat lower temperature in the United States, and a mild

insular climate in the Arctic regions. In each successive period the

climate becomes somewhat less tropical; but down to the Upper Miocene it

remains warm temperate in Central Europe, and cold temperate within the

polar area, with not a trace of any intervening periods of Arctic cold. It

then gradually cools down and merges through the Pliocene into the glacial

epoch in Europe, while in the Arctic zone there is a break in the record

between the Miocene and the recent glacial deposits.[20]

{79}

Accepting this as a substantially correct account of the general climatic

aspect of the Tertiary period in the northern hemisphere, let us see

whether the principles we have already laid down will enable us to give a

satisfactory explanation of its causes.

\_The Causes of mild Arctic Climates.\_--In his remarkable series of papers

on "Ocean Currents," the late Dr. James Croll has proved, with a wealth of

argument and illustration whose cogency is irresistible, that the very

habitability of our globe is due to the equalizing climatic effects of the

waters of the ocean; and that it is to the same cause that we owe, either

directly or indirectly, almost all the chief diversities of climate between

places situated in the same latitude. Owing to the peculiar distribution of

land and sea upon the globe, more than its fair proportion of the warm

equatorial waters is directed towards the western shores of Europe, the

result being that the British Isles, Norway, and Spitzbergen, have all a

milder climate than any other parts of the globe in corresponding

latitudes. A very small portion of the Arctic regions, however, obtains

this benefit, and it thus remains, generally speaking, a land of snow and

ice, with too short a summer to nourish more than a very scanty and

fugitive vegetation. The only other opening than that between Iceland and

Britain by which warm water penetrates within the Arctic circle, is through

Behring's Straits; but this is both shallow and limited in width, and the

consequence is that the larger part of the warm currents of the Pacific

turns back along the shores of the Aleutian Islands and North-west America,

while a very small quantity enters the icy ocean.

But if there were other and wider openings into the Arctic Ocean, a vast

quantity of the heated water which is now turned backward would enter it,

and would produce an amelioration of the climate of which we can hardly

form a conception. A great amelioration of climate would also be caused by

the breaking up or the lowering of such {80} Arctic highlands as now favour

the accumulation of ice; while the interpenetration of the sea into any

part of the great continents in the tropical or temperate zones would again

tend to raise the winter temperature, and render any long continuance of

snow in their vicinity almost impossible.

Now geologists have proved, quite independently of any such questions as we

are here discussing, that changes of the very kinds above referred to have

occurred during the Tertiary period; and that there has been, speaking

broadly, a steady change from a comparatively fragmentary and insular

condition of the great north temperate lands in early Tertiary times, to

that more compact and continental condition which now prevails. It is, no

doubt, difficult and often impossible to determine how long any particular

geographical condition lasted, or whether the changes in one country were

exactly coincident with those in another; but it will be sufficient for our

purpose briefly to indicate those more important changes of land and sea

during the Tertiary period, which must have produced a decided effect on

the climate of the northern hemisphere.

\_Geographical Changes Favouring Mild Northern Climates in Tertiary

Times.\_--The distribution of the Eocene and Miocene formations shows, that

during a considerable portion of the Tertiary period, an inland sea, more

or less occupied by an archipelago of islands, extended across Central

Europe between the Baltic and the Black and Caspian Seas, and thence by

narrower channels south-eastward to the valley of the Euphrates and the

Persian Gulf, thus opening a communication between the North Atlantic and

the Indian Oceans. From the Caspian also a wide arm of the sea extended

during some part of the Tertiary epoch northwards to the Arctic Ocean, and

there is nothing to show that this sea may not have been in existence

during the whole Tertiary period. Another channel probably existed over

Egypt[21] into the eastern {81} basin of the Mediterranean and the Black

Sea; while it is probable that there was a communication between the Baltic

and the White Sea, leaving Scandinavia as an extensive island. Turning to

India, we find that an arm of the sea of great width and depth extended

from the Bay of Bengal to the mouths of the Indus; while the enormous

depression indicated by the presence of marine fossils of Eocene age at a

height of 10,500 feet in Western Tibet, renders it not improbable that a

more direct channel across Afghanistan may have opened a communication

between the West Asiatic and Polar seas.

It may be said that the changes here indicated are not warranted by an

actual knowledge of continuous Tertiary deposits over the situations of the

alleged marine channels; but it is no less certain that the seas in which

any particular strata were deposited were \_always\_ more extensive than the

fragments of those strata now existing, and \_often\_ immensely more

extensive. The Eocene deposits of Europe, for example, have certainly

undergone enormous denudation both marine and subaÃ«rial, and may have once

covered areas where we now find older deposits (as the chalk once covered

the weald), while a portion of them may lie concealed under Miocene,

Pliocene, or recent beds. We find them widely scattered over Europe and

Asia, and often elevated into lofty mountain ranges; and we should

certainly err far more seriously in confining the Eocene seas to the exact

areas where we now find Eocene rocks, than in liberally extending them, so

as to connect the several detached portions of the formation whenever there

is no valid argument against our doing so. Considering then, that some one

or more of the sea-communications here indicated almost certainly existed

during Eocene and Miocene times, let us endeavour to estimate the probable

effect such communications would have upon the climate of the northern

hemisphere.

\_The Indian Ocean as a Source of Heat in Tertiary Times.\_--If we compare

the Indian Ocean with the South Atlantic we shall see that the position and

outline of the former are very favourable for the accumulation of a large

body of warm water moving northwards. Its southern {82} opening between

South Africa and Australia is very wide, and the tendency of the

trade-winds would be to concentrate the currents towards its north-western

extremity, just where the two great channels above described formed an

outlet to the northern seas. As will be shown in our nineteenth chapter,

there was probably, during the earlier portion of the Tertiary period at

least, several large islands in the space between Madagascar and South

India; but these had wide and deep channels between them, and their

existence may have been favourable to the conveyance of heated water

northward, by concentrating the currents, and thus producing massive bodies

of moving water analogous to the Gulf Stream of the Atlantic.[22] Less heat

would thus be lost by evaporation and radiation in the tropical zone, and

an impulse would be acquired which would carry the warm water into the

north polar area. About the same period Australia was probably divided into

two islands, separated by a wide channel in a north and south direction

(see Chapter XXII.), and through this another current would almost

certainly set northwards, and be directed to the north-west by the southern

extension of Malayan Asia. The more insular condition at this period of

Australia, India, and North Africa, with the depression and probable

fertility of the Central Asiatic plateau, would lead to the Indian Ocean

being traversed by regular trade-winds instead of by variable monsoons, and

thus the constant \_vis a tergo\_, which is so efficient in the Atlantic,

would keep up a steady and powerful current towards the northern parts of

the Indian Ocean, and thence through the midst of the European archipelago

to the northern seas.

Now it is quite certain that such a condition as we have here sketched out

would produce a wonderful effect on the climate of Central Europe and

Western and Northern Asia. Owing to the warm currents being concentrated in

inland seas instead of being dispersed over a wide ocean like the {83}

North Atlantic, much more heat would be conveyed into the Arctic Ocean, and

this would altogether prevent the formation of ice on the northern shores

of Asia, which continent did not then extend nearly so far north and was

probably deeply inter-penetrated by the sea. This open ocean to the north,

and the warm currents along all the northern lands, would so equalise

temperature, that even the northern parts of Europe might then have enjoyed

a climate fully equal to that of the warmer parts of New Zealand at the

present day, and might have well supported the luxuriant vegetation of the

Miocene period, even without any help from similar changes in the western

hemisphere.[23]

\_Condition of North America during the Tertiary Period.\_--But changes of a

somewhat similar character have also taken place in America and the

Pacific. An enormous area west of the Mississippi, extending over much of

the Rocky Mountains, consists of marine Cretaceous beds 10,000 feet thick,

indicating great and long-continued subsidence, and an insular condition of

Western America with a sea probably extending northwards to the Arctic

Ocean. As marine Tertiary deposits are found conformably overlying these

Cretaceous strata, Professor Dana is of opinion that the great elevation of

this part of America did not begin till early Tertiary times. Other

Tertiary beds in California, Alaska, Kamschatka, the Mackenzie River, the

Parry Islands, and Greenland, indicate partial submergence {84} of all

these lands with the possible influx of warm water from the Pacific; and

the considerable elevation of some of the Miocene beds in Greenland and

Spitzbergen renders it probable that these countries were then much less

elevated, in which case only their higher summits would be covered with

perpetual snow, and no glaciers would descend to the sea.

In the Pacific there was probably an elevation of land counterbalancing, to

some extent, the great depression of so much of the northern continents.

Our map in Chapter XV. shows the islands that would be produced by an

elevation of the great shoals under a thousand fathoms deep, and it is seen

that these all trend in a south-east and north-west direction, and would

thus facilitate the production of definite currents impelled by the

south-east trades towards the north-west Pacific, where they would gain

access to the polar seas through Behring's Straits, which were, perhaps,

sometimes both wider and deeper than at present.

\_Effect of these Changes on the Climate of the Arctic Regions.\_--These

various changes of sea and land, all tending towards a transference of heat

from the equator to the north temperate zone, were not improbably still

further augmented by the existence of a great inland South American sea

occupying what are now the extensive valleys of the Amazon and Orinoco, and

forming an additional reservoir of super-heated water to add to the supply

poured into the North Atlantic.

It is not of course supposed that all the modifications here indicated

co-existed at the same time. We have good reason to believe, from the known

distribution of animals in the Tertiary period, that land-communications

have at times existed between Europe or Asia and North America, either by

way of Behring's Straits, or by Iceland, Greenland, and Labrador. But the

same evidence shows that these land-communications were the exception

rather than the rule, and that they occurred only at long intervals and for

short periods, so as at no time to bring about anything like a complete

interchange of the productions of the two continents.[24] We may therefore

admit that the {85} communication between the tropical and Arctic oceans

was occasionally interrupted in one or other direction; but if we look at a

globe instead of a Mercator's chart of the world, we shall see that the

disproportion between the extent of the polar and tropical seas is so

enormous that a single wide opening, with an adequate impulse to carry in a

considerable stream of warm water, would be amply sufficient for the

complete abolition of polar snow and ice, when aided by the absence of any

great areas of high land within the polar circle, such high land being, as

we have seen, essential to the production of perpetual snow even at the

present time.

Those who wish to understand the effect of oceanic currents in conveying

heat to the north temperate and polar regions, should study the papers of

Dr. Croll already referred to. But the same thing is equally well shown by

the facts of the actual distribution of heat due to the Gulf Stream. The

difference between the mean annual temperatures of the opposite coasts of

Europe and America is well known and has been already quoted, but the

difference of their mean \_winter\_ temperature is still more striking, and

it is this which concerns us as more especially affecting the distribution

of vegetable and animal life. Our mean winter temperature in the west of

England is the same as that of the Southern United States, as well as that

of Shanghai in China, both about twenty degrees of latitude further south;

and as we go northward the difference increases, so that the winter climate

of Nova Scotia in Lat. 45Â° is found within the Arctic circle on the coast

of Norway; and if the latter country did not consist almost wholly of

precipitous snow-clad mountains, it would be capable of supporting most of

the vegetable products of the American coast in the latitude of

Bordeaux.[25]

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With these astounding facts before us, due wholly to the transference of a

portion of the warm currents of the Atlantic to the shores of Europe, even

with all the disadvantages of an icy sea to the north-east and ice-covered

Greenland to the north-west, how can we doubt the enormously greater effect

of such a condition of things as has been shown to have existed during the

Tertiary epoch? Instead of \_one\_ great stream of warm water spreading

widely over the North Atlantic and thus losing the greater part of its

store of heat \_before\_ it reaches the Arctic seas, we should have \_several\_

streams conveying the heat of far more extensive tropical oceans by

comparatively narrow inland channels, thus being able to transfer a large

proportion of their heat \_into\_ the northern and Arctic seas. The heat that

they gave out during the passage, instead of being widely dispersed by

winds and much of it lost in the higher atmosphere, would directly

ameliorate the climate of the continents they passed through, and prevent

all accumulation of snow except on the loftiest mountains. The formation of

ice in the Arctic seas would then be impossible; and the mild winter

climate of the latitude of North {87} Carolina, which by the Gulf Stream is

transferred 20Â° northwards to our islands, might certainly, under the

favourable conditions which prevailed during the Cretaceous, Eocene, and

Miocene periods, have been carried another 20Â° north to Greenland and

Spitzbergen; and this would bring about exactly the climate indicated by

the fossil Arctic vegetation. For it must be remembered that the Arctic

summers are, even now, really hotter than ours, and if the winter's cold

were abolished and all ice-accumulation prevented, the high northern lands

would be able to support a far more luxuriant summer vegetation than is

possible in our unequal and cloudy climate.[26]

\_Effect of High Excentricity on the Warm Polar Climates.\_--If the

explanation of the cause of the glacial epoch given in the last chapter is

a correct one, it will, I believe, follow that changes in the amount of

excentricity will produce no important alteration of the climates of the

temperate and Arctic zones so long as favourable geographical conditions,

such as have been now sketched out, render the accumulation of ice

impossible. The effect of a high excentricity in producing a glacial epoch

was shown to be due to the capacity of snow and ice for storing up cold,

and its singular power (when in large masses) of preserving itself unmelted

under a hot sun by itself causing the interposition of a protective

covering of cloud and vapour. But mobile currents of water have no such

power of {88} accumulating and storing up heat or cold from one year to

another, though they do in a pre-eminent degree possess the power of

equalising the temperature of winter and summer and of conveying the

superabundant heat of the tropics to ameliorate the rigour of the Arctic

winters. However great was the difference between the amount of heat

received from the sun in winter and summer in the Arctic zone during a

period of high excentricity and winter in \_aphelion\_, the inequality would

be greatly diminished by the free ingress of warm currents to the polar

area; and if this was sufficient to prevent any accumulation of ice, the

summers would be warmed to the full extent of the powers of the sun during

the long polar day, which is such as to give the pole at midsummer actually

more heat during the twenty-four hours than the equator receives during its

day of twelve hours. The only difference, then, that would be directly

produced by the changes of excentricity and precession would be, that the

summers would be at one period almost tropical, at the other of a more mild

and uniform temperate character; while the winters would be at one time

somewhat longer and colder, but never, probably, more severe than they are

now in the west of Scotland.

But though high excentricity would not directly modify the mild climates

produced by the state of the northern hemisphere which prevailed during

Cretaceous, Eocene, and Miocene times, it might indirectly affect it by

increasing the mass of Antarctic ice, and thus increasing the force of the

trade-winds and the resulting northward-flowing warm currents. Now there

are many peculiarities in the distribution of plants and of some groups of

animals in the southern hemisphere, which render it almost certain that

there has sometimes been a greater extension of the Antarctic lands during

Tertiary times; and it is therefore not improbable that a more or less

glaciated condition may have been a long persistent feature of the southern

hemisphere, due to the peculiar distribution of land and sea which favours

the production of ice-fields and glaciers. And as we have seen that during

the last three million years the excentricity has been almost always much

higher than {89} it is now, we should expect that the quantity of ice in

the southern hemisphere will usually have been greater, and will thus have

tended to increase the force of those oceanic currents which produce the

mild climates of the northern hemisphere.

\_Evidences of Climate in the Secondary and PalÃ¦ozoic Epochs.\_--We have

already seen, that so far back as the Cretaceous period there is the most

conclusive evidence of the prevalence of a very mild climate not only in

temperate but also in Arctic lands, while there is no proof whatever, or

even any clear indication, of early glacial epochs at all comparable in

extent and severity with that which has so recently occurred; and we have

seen reason to connect this state of things with a distribution of land and

sea highly favourable to the transference of warm water from equatorial to

polar latitudes. So far as we can judge by the plant-remains of our own

country, the climate appears to have been almost tropical in the Lower

Eocene period; and as we go further back we find no clear indications of a

higher, but often of a lower temperature, though always warmer or more

equable than our present climate. The abundant corals and reptiles of the

Oolite and Lias indicate equally tropical conditions; but further back, in

the Trias, the flora and fauna, in the British area, become poorer, and

there is nothing incompatible with a climate no warmer than that of the

Upper Miocene. This poverty is still more marked in the Permian formation,

and it is here that some indications of ice-action are found in the Lower

Permian conglomerates of the west of England. These beds contain abundant

fragments of various rocks, often angular and sometimes weighing half a

ton, while others are partially rounded, and have polished and striated

surfaces, just like the stones of the "till." They lie confusedly bedded in

a red unstratified marl, and some of them can be traced to the Welsh hills

from twenty to fifty miles distant. This remarkable formation was first

pointed out as proving a remote glacial period, by Professor Ramsay; and

Sir Charles Lyell agreed that this is the only possible explanation that,

with our present knowledge, we can give of them.

Permian breccias are also found in Ireland, containing {90} blocks of

Silurian and Old Red sandstone rocks which Professor Hull believes could

only have been carried by floating ice. Similar breccias occur in the south

of Scotland, and these are stated to be "overlain by a deposit of glacial

age, so similar to the breccia below as to be with difficulty distinguished

from it."[27]

These numerous physical indications of ice-action over a considerable area

during the same geological period, coinciding with just such a poverty of

organic remains as might be produced by a very cold climate, are very

important, and seem clearly to indicate that at this remote period

geographical conditions were such as to bring about a glacial epoch, or

perhaps only local glaciation, in our part of the world.

Boulder-beds also occur in the Carboniferous formation, both in Scotland,

on the continent of Europe, and in North America; and Professor Dawson

considers that he has detected true glacial deposits of the same age in

Nova Scotia. Boulder-beds also occur in the Silurian rocks of Scotland and

North America, and according to Professor Dawson, even in the Huronian,

older than our Cambrian. None of these indications are however so

satisfactory as those of Permian age, where we have the very kind of

evidence we looked for in vain throughout the whole of the Tertiary and

Secondary periods. Its presence in several localities in such ancient rocks

as the Permian is not only most important as indicating a glacial epoch of

some kind in PalÃ¦ozoic times, but confirms us in the validity of our

conclusion, that the \_total\_ absence of any such evidence throughout the

Tertiary and Secondary epochs demonstrates the absence of recurring glacial

epochs in the northern hemisphere, notwithstanding the frequent recurrence

of periods of high excentricity.

\_Warm Arctic Climates in Early Secondary and PalÃ¦ozoic Times.\_--The

evidence we have already adduced of the mild climates prevailing in the

Arctic regions throughout the Miocene, Eocene, and Cretaceous periods is

supplemented by a considerable body of facts relating to still earlier

epochs.

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In the Jurassic period, for example, we have proofs of a mild Arctic

climate, in the abundant plant-remains of East Siberia and Amurland, with

less productive deposits in Spitzbergen, and at Ando in Norway just within

the Arctic circle. But even more remarkable are the marine remains found in

many places in high northern latitudes, among which we may especially

mention the numerous ammonites and the vertebrÃ¦ of huge reptiles of the

genera Ichthyosaurus and Teleosaurus found in the Jurassic deposits of the

Parry Islands in 77Â° N. Lat.

In the still earlier Triassic age, nautili and ammonites inhabited the seas

of Spitzbergen, where their fossil remains are now found.

In the Carboniferous formation we again meet with plant-remains and beds of

true coal in the Arctic regions. Lepidodendrons and Calamites, together

with large spreading ferns, are found at Spitzbergen, and at Bear Island in

the extreme north of Eastern Siberia; while marine deposits of the same age

contain abundance of large stony corals.

Lastly, the ancient Silurian limestones, which are widely spread in the

high Arctic regions, contain abundance of corals and cephalopodous mollusca

resembling those from the same deposits in more temperate lands.

\_Conclusions as to the Climates of Tertiary and Secondary Periods.\_--If now

we look at the whole series of geological facts as to the animal and

vegetable productions of the Arctic regions in past ages, it is certainly

difficult to avoid the conclusion that they indicate a climate of a

uniformly temperate or warm character. Whether in Miocene, Upper or Lower

Cretaceous, Jurassic, Triassic, Carboniferous or Silurian times, and in all

the numerous localities extending over more than half the polar regions, we

find one uniform climatic aspect in the fossils. This is quite inconsistent

with the theory of alternate cold and mild epochs during phases of high

excentricity, and persistent cold epochs when the excentricity was as low

as it is now or lower, for that would imply that the duration of cold

conditions was \_greater\_ than that of warm. Why then should the fauna and

flora of the cold epochs \_never\_ be {92} preserved? Mollusca and many other

forms of life are abundant in the Arctic seas, and there is often a

luxuriant dwarf woody vegetation on the land, yet in no one case has a

single example of such a fauna or flora been discovered of a date anterior

to the last glacial epoch. And this argument is very much strengthened when

we remember that an exactly analogous series of facts is found over all the

temperate zones. Everywhere we have abundant floras and faunas indicating

warmer conditions than such as now prevail, but never in a single instance

one which as clearly indicates colder conditions. The fact that drift with

Arctic shells was deposited during the last glacial epoch, as well as

gravels and crag with the remains of arctic animals and plants, shows us

that there is nothing to prevent such deposits being formed in cold as well

as in warm periods; and it is quite impossible to believe that in every

place and at all epochs all records of the former have been destroyed,

while in a considerable number of instances those of the latter have been

preserved. When to this uniform testimony of the palÃ¦ontological evidence

we add the equally uniform absence of any indication of those ice-borne

rocks, boulders, and drift, which are the constant and necessary

accompaniment of every period of glaciation, and which must inevitably

pervade all the marine deposits formed over a wide area so long as the

state of glaciation continues, we are driven to the conclusion that the

last glacial epoch of the northern hemisphere was exceptional, and was not

preceded by numerous similar glacial epochs throughout Tertiary and

Secondary time.

But although glacial epochs (with the one or two exceptions already

referred to) were certainly absent, considerable changes of climate may

have frequently occurred, and these would lead to important changes in the

organic world. We can hardly doubt that some such change occurred between

the Lower and Upper Cretaceous periods, the floras of which exhibit such an

extraordinary contrast in general character. We have also the testimony of

Mr. J. S. Gardner, who has long worked at the fossil floras of the Tertiary

deposits, and who states, that {93} there is strong negative and some

positive evidence of alternating warmer and colder conditions, not glacial,

contained not only in English Eocene, but all Tertiary beds throughout the

world.[28] In the case of marine faunas it is more difficult to judge, but

the numerous changes in the fossil remains from bed to bed only a few feet

and sometimes a few inches apart, may be sometimes due to change of

climate; and when it is recognised that such changes have probably occurred

at all geological epochs and their effects are systematically searched for,

many peculiarities in the distribution of organisms through the different

members of one deposit may be traced to this cause.

\_General View of Geological Climates as dependent on the Physical Features

of the Earth's Surface.\_--In the preceding chapters I have earnestly

endeavoured to arrive at an explanation of geological climates in the

temperate and Arctic zones, which should be in harmony with the great body

of geological facts now available for their elucidation. If my conclusions

as here set forth diverge considerably from those of Dr. Croll, it is not

from any want of appreciation of his facts and arguments, since for many

years I have upheld and enforced his views to the best of my ability. But a

careful re-examination of the whole question has now convinced me that an

error has been made in estimating the comparative effect of geographical

and astronomical causes on changes of climate, and that, while the latter

have undoubtedly played an important part in bringing about the glacial

epoch, it is to the former that the mild climates of the Arctic regions are

almost entirely due. If I have now succeeded in approaching to a true

solution of this difficult problem, I owe it mainly to the study of Dr.

Croll's writings, since my theory is entirely based on the facts and

principles so clearly set forth in his admirable papers on "Ocean Currents

in relation to the Distribution of Heat over the Globe." The main features

of this theory as distinct from that of Dr. Croll I will now endeavour to

summarise.

Looking at the subject broadly, we see that the climatic {94} condition of

the northern hemisphere is the result of the peculiar distribution of land

and water upon the globe; and the general permanence of the position of the

continental and oceanic areas--which we have shown to be proved by so many

distinct lines of evidence--is also implied by the general stability of

climate throughout long geological periods. The land surface of our earth

appears to have always consisted of three great masses in the north

temperate zone, narrowing southward, and terminating in three comparatively

narrow extremities represented by Southern America, South Africa, and

Australia. Towards the north these masses have approached each other, and

have sometimes become united; leaving beyond them a considerable area of

open polar sea. Towards the south they have never been much further

prolonged than at present, but far beyond their extremities an extensive

mass of land has occupied the south polar area.

This arrangement is such as would cause the northern hemisphere to be

always (as it is now) warmer than the southern, and this would lead to the

preponderance of northward winds and ocean currents, and would bring about

the concentration of the latter in three great streams carrying warmth to

the north-polar regions. These streams would, as Dr. Croll has so well

shown, be greatly increased in power by the glaciation of the south polar

land; and whenever any considerable portion of this land was elevated, such

a condition of glaciation would certainly be brought about, and would be

heightened whenever a high degree of excentricity prevailed.

It is now the general opinion of geologists that the great continents have

undergone a process of development from earlier to later times. Professor

Dana appears to have been the first who taught it explicitly in the case of

the North American continent, and he has continued the development of his

views from 1856, when he discussed the subject in the \_American Journal\_,

to the later editions of his \_Manual of Geology\_ in which the same views

are extended to all the great continents. He says:--

"The North American continent, which since early {95} time had been

gradually expanding in each direction from the northern Azoic, eastward,

westward, and southward, and which, after the PalÃ¦ozoic, was finished in

its rocky foundation, excepting on the borders of the Atlantic and Pacific

and the area of the Rocky Mountains, had reached its full expansion at the

close of the Tertiary period. The progress from the first was uniform and

systematic: the land was at all times simple in outline; and its

enlargement took place with almost the regularity of an exogenous

plant."[29]

A similar development undoubtedly took place in the European area, which

was apparently never so compact and so little interpenetrated by the sea as

it is now, while Europe and Asia have only become united into one unbroken

mass since late Tertiary times.

If, however, the greater continents have become more compact and massive

from age to age, and have received their chief extensions northward at a

comparatively recent period, while the Antarctic lands had a corresponding

but somewhat earlier development, we have all the conditions requisite to

explain the persistence, with slight fluctuations, of warm climates far

into the north-polar area throughout PalÃ¦ozoic, Mesozoic, and Tertiary

times. At length, during the latter part of the Tertiary epoch, a

considerable elevation took place, closing up several of the water passages

to the north, and raising up extensive areas in the Arctic regions to

become the receptacle of snow and ice-fields. This elevation is indicated

by the abundance of Miocene and the absence of Pliocene deposits in the

Arctic zone and the considerable altitude of many Miocene rocks in Europe

and North America; and the occurrence at this time of a long-continued

period of high excentricity necessarily brought on the glacial epoch in the

manner already described in our last chapter. A depression seems to have

occurred during the glacial period itself in North America as in Britain,

but this may have been due partly to the weight of the ice and partly to a

rise of the ocean {96} level caused by the earth's centre of gravity being

shifted towards the north.

We thus see that the last glacial epoch was the climax of a great process

of continental development which had been going on throughout long

geological ages; and that it was the direct consequence of the north

temperate and polar land having attained a great extension and a

considerable altitude just at the time when a phase of very high

excentricity was coming on. Throughout earlier Tertiary and Secondary times

an equally high excentricity often occurred, but it never produced a

glacial epoch, because the north temperate and polar areas had less high

land, and were more freely open to the influx of warm oceanic currents. But

wherever great plateaux with lofty mountains occurred in the temperate zone

a considerable \_local\_ glaciation might be produced, which would be

specially intense during periods of high excentricity; and it is to such

causes we must impute the indications of ice-action in the vicinity of the

Alps during the Tertiary period. The Permian glaciation appears to have

been more extensive, and it is quite possible that at this remote epoch a

sufficient mass of high land existed in our area and northwards towards the

pole, to have brought on a true glacial period comparable with that which

has so recently passed away.

\_Estimate of the comparative effects of Geographical and Astronomical

Causes in producing Changes of Climate.\_--It appears then, that while

geographical and physical causes alone, by their influence on ocean

currents, have been the main agents in producing the mild climates which

for such long periods prevailed in the Arctic regions, the concurrence of

astronomical causes--high excentricity with winter in \_aphelion\_--was

necessary to the production of the great glacial epoch. If we reject this

latter agency, we shall be obliged to imagine a concurrence of geographical

changes at a very recent period of which we have no evidence. We must

suppose, for example, that a large part of the British Isles--Scotland,

Ireland, and Wales at all events--were simultaneously elevated so as to

bring extensive areas above the line of perpetual snow; that {97} about the

same time Scandinavia, the Alps, and the Pyrenees received a similar

increase of altitude; and that, almost simultaneously, Eastern North

America, the Sierra Nevada of California, the Caucasus, Lebanon, the

southern mountains of Spain, the Atlas range, and the Himalayas, were each

some thousands of feet higher than they are now; for all these mountains

present us with indications of a recent extension of their glaciers, in

superficial phenomena so similar to those which occur in our own country

and in Western Europe, that we cannot suppose them to belong to a different

epoch. Such a supposition is rendered more difficult by the general

concurrence of scientific testimony to a partial submergence during the

glacial epoch, not only in all parts of Britain, but in North America,

Scandinavia, and, as shown by the wide extension of the drift, in Northern

Europe; and when to this we add the difficulty of understanding how any

probable addition to the altitude of our islands could have brought about

the extreme amount of glaciation which they certainly underwent, and when,

further, we know that a phase of very high excentricity did occur at a

period which is generally admitted to agree well with physical evidence of

the time elapsed since the cold passed away, there seems no sufficient

reason why such an agency should be ignored.

No doubt a prejudice has been excited against it in the minds of many

geologists, by its being thought to lead \_necessarily\_ to frequently

recurring glacial epochs throughout all geological time. But I have here

endeavoured to show that this is \_not\_ a necessary consequence of the

theory, because a concurrence of favourable geographical conditions is

essential to the initiation of a glaciation, which when once initiated has

a tendency to maintain itself throughout the varying phases of precession

occurring during a period of high excentricity. When, however, geographical

conditions favour warm Arctic climates--as it has been shown they have done

throughout the larger portion of geological time--then changes of

excentricity, to however great an extent, have no tendency to bring about a

state of glaciation, because warm oceanic currents have a {98}

preponderating influence, and without very large areas of high northern

land to act as condensers, no perpetual snow is possible, and hence the

initial process of glaciation does not occur.

The theory as now set forth should commend itself to geologists, since it

shows the direct dependence of climate on physical processes, which are

guided and modified by those changes in the earth's surface which geology

alone can trace out. It is in perfect accord with the most recent teachings

of the science as to the gradual and progressive development of the earth's

crust from the rudimentary formations of the Azoic age, and it lends

support to the view that no inportant[\*\*important] departure from the great

lines of elevation and depression originally marked out on the earth's

surface has ever taken place.

It also shows us how important an agent in the production of a habitable

globe with comparatively small extremes of climates over its whole area, is

the great disproportion between the extent of the land and the water

surfaces. For if these proportions had been reversed, large areas of land

would necessarily have been removed from the beneficial influence of

aqueous currents or moisture-laden winds; and slight geological changes

might easily have led to half the land surface becoming covered with

perpetual snow and ice, or being exposed to extremes of summer heat and

winter cold, of which our water-permeated globe at present affords no

example. We thus see that what are usually regarded as geographical

anomalies--the disproportion of land and water, the gathering of the land

mainly into one hemisphere, and the singular arrangement of the land in

three great southward-pointing masses--are really facts of the greatest

significance and importance, since it is to these very anomalies that the

universal spread of vegetation and the adaptability of so large a portion

of the earth's surface for human habitation is directly due.

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CHAPTER X

THE EARTH'S AGE, AND THE RATE OF DEVELOPMENT OF ANIMALS AND PLANTS

Various Estimates of Geological Time--Denudation and Deposition of

Strata as a Measure of Time--How to Estimate the Thickness of the

Sedimentary Rocks--How to Estimate the Average Rate of Deposition of

the Sedimentary Rocks--The Rate of Geological Change Probably greater

in very Remote Times--Value of the Preceding Estimate of Geological

Time--Organic Modification Dependent on Change of

Conditions--Geographical Mutations as a Motive Power in bringing about

Organic Changes--Climatal Revolutions as an Agent in Producing Organic

Changes--Present Condition of the Earth one of Exceptional Stability as

Regards Climate--Date of last Glacial Epoch and its Bearing on the

Measurement of Geological Time--Concluding Remarks.

The subjects discussed in the last three chapters introduce us to a

difficulty which has hitherto been considered a very formidable one--that

the maximum age of the habitable earth, as deduced from physical

considerations, does not afford sufficient time either for the geological

or the organic changes of which we have evidence. Geologists continually

dwell on the slowness of the processes of upheaval and subsidence, of

denudation of the earth's surface, and of the formation of new strata;

while on the theory of development, as expounded by Mr. Darwin, the

variation and modification of organic forms is also a very slow process,

and has usually been considered to require an {100} even longer series of

ages than might satisfy the requirements of physical geology alone.

As an indication of the periods usually contemplated by geologists, we may

refer to Sir Charles Lyell's calculation in the tenth edition of his

\_Principles of Geology\_ (omitted in later editions), by which he arrived at

240 millions of years as having probably elapsed since the Cambrian

period--a very moderate estimate in the opinion of most geologists. This

calculation was founded on the rate of modification of the species of

mollusca; but much more recently Professor Haughton has arrived at nearly

similar figures from a consideration of the rate of formation of rocks and

their known maximum thickness, whence he deduces a maximum of 200 millions

of years for the whole duration of geological time, as indicated by the

series of stratified formations.[30] But in the opinion of all our first

naturalists and geologists, the period occupied in the formation of the

known stratified rocks only represents a portion, and perhaps a small

portion, of geological time. In the sixth edition of the \_Origin of

Species\_ (p. 286), Mr. Darwin says: "Consequently, if the theory be true,

it is indisputable that before the lowest Cambrian stratum was deposited

long periods elapsed, as long as, or probably far longer than, the whole

interval from the Cambrian age to the present day; and that during these

vast periods the world swarmed with living creatures." Professor Huxley, in

his anniversary address to the Geological Society in 1870, 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 PalÃ¦ozoic 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 {101} mammalian type occur perfectly

developed in the Eocene formation. What countless ages 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 PalÃ¦ozoic times. Similar evidence

is afforded by reptiles, of which Professor Huxley says: "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 PalÃ¦ozoic times

we must go before we can hope to arrive at that common stock from which the

crocodiles, lizards, \_Ornithoscelida\_, and \_Plesiosauria\_, which had

attained so great a development in the Triassic epoch, must have been

derived." Professor Ramsay has expressed similar views, derived from a

general study of the whole series of geological formations and their

contained fossils. He says, speaking of the abundant, varied, and

well-developed fauna of the Cambrian period: "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."[31]

These opinions, and the facts on which they are founded, are so weighty,

that we can hardly doubt that, if the time since the Cambrian epoch is

correctly estimated at 200 millions of years, the date of the commencement

of life on the earth cannot be much less than 500 millions; while it may

not improbably have been longer, because the reaction of {102} the organism

under changes of the environment is believed to have been less active in

low and simple, than in high and complex forms of life, and thus the

processes of organic development may for countless ages have been

excessively slow.

But according to the physicists, no such periods as are here contemplated

can be granted. From a consideration of the possible sources of the heat of

the sun, as well as from 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 beneath the surface, Sir William Thomson

concludes that the crust of the earth cannot have been solidified much

longer than 100 million years (the maximum possible being 400 millions),

and this conclusion is held by Dr. Croll and other men of eminence to be

almost indisputable.[32] It will therefore be well to consider on what data

the calculations of geologists have been founded, and how far the views

here set forth, as to frequent changes of climate throughout all geological

time, may affect the rate of biological change.

\_Denudation and Deposition of Strata as a Measure of Time.\_--The materials

of all the stratified rocks of the globe have been obtained from the dry

land. Every point of the surface is exposed to the destructive influences

of sun and wind, frost, snow, and rain, which break up and wear away the

hardest rocks as well as the softer deposits, and by means of rivers convey

the worn material to the sea. The existence of a considerable depth of soil

over the greater part of the earth's surface; of vast heaps of rocky

\_dÃ©bris\_ at the foot of every inland cliff; of enormous deposits of gravel,

sand, and loam; as well as the shingle, pebbles, sand or mud, of every

sea-shore, alike attest the universality of this destructive agency. It is

no less clearly shown by the way in which almost every drop of running

water--whether in gutter, brooklet, stream or large river--becomes

discoloured after each heavy rainfall, since the matter which causes this

discolouration must be derived from the surface {103} of the country, must

always pass from a higher to a lower level, and must ultimately reach the

sea, unless it is first deposited in some lake, or by the overflowing of a

river goes to form an alluvial plain. The universality of this subaÃ«rial

denudation, both as regards space and time, renders it certain that its

cumulative effects must be very great; but no attempt seems to have been

made to determine the magnitude of these effects till Mr. Alfred Tylor, in

1853,[33] pointed out that by measuring the quantity of solid matter

brought down by rivers (which can be done with considerable accuracy), we

may obtain the amount of lowering of the land-area, and also the rise of

the ocean level, owing to the quantity of matter deposited on its floor. A

few years later Dr. Croll applied the same method in more detail to an

estimate of the amount by which the land is lowered in a given period; and

the validity of this method has been upheld by Sir A. Geikie, Sir Charles

Lyell, and all our best geologists, as affording a means of actually

determining with some approach to accuracy, the time occupied by one

important phase of geological change.

The quantity of matter carried away from the land by a river is greater

than at first sight appears, and is more likely to be under- than

over-estimated. By taking samples of water near the mouth of a river (but

above the influence of the tide) at a sufficient number of points in its

channel and at different depths, and repeating this daily or at other short

intervals throughout the year, it is easy to determine the quantity of

solid matter held in suspension and solution; and if corresponding

observations determine the quantity of water that is discharged, the total

amount of solid matter brought down annually may be calculated. But besides

this, a considerable quantity of sand or even gravel is carried along the

bottom or bed of the river, and this has rarely been estimated, so that the

figures hitherto obtained are usually under the real quantities. There is

also another source of error caused by the quantity of matter the river may

deposit in lakes or in flooded lands during its course, for this adds to

the amount of denudation performed by the river, although {104} the matter

so deposited does not come down to the sea. After a careful examination of

all the best records, Sir A. Geikie arrives at the following results, as to

the quantity of matter removed by seven rivers from their basins, estimated

by the number of years required to lower the whole surface an average of

one foot:

The Mississippi removes one foot in 6,000 years.

,, Ganges ,, ,, 2,358 ,,

,, Hoang Ho ,, ,, 1,464 ,,

,, Rhone ,, ,, 1,528 ,,

,, Danube ,, ,, 6,846 ,,

,, Po ,, ,, 729 ,,

,, Nith ,, ,, 4,723 ,,

Here we see an intelligible relation between the character of the river

basin and the amount of denudation. The Mississippi has a large portion of

its basin in an arid country, and its sources are either in forest-clad

plateaux or in mountains free from glaciers and with a scanty rainfall. The

Danube flows through Eastern Europe where the rainfall is considerably less

than in the west, while comparatively few of its tributaries rise among the

loftiest Alps. The proportionate amounts of denudation being then what we

might expect, and as all are probably under rather than over the truth, we

may safely take the average of them all as representing an amount of

denudation which, if not true for the whole land surface of the globe, will

certainly be so for a very considerable proportion of it. This average is

almost exactly one foot in three thousand years.[34] The mean altitude of

the several {105} continents has been recently estimated by Mr. John

Murray,[35] to be as follows: Europe 939 feet, Asia 3,189 feet, Africa 2020

feet, North America 1,888 feet, and South America 2,078 feet. At the rate

of denudation above given, it results that, were no other forces at work,

Europe would be planed down to the sea-level in about two million eight

hundred thousand years; while if we take a somewhat slower rate for North

America, that continent might last about four or five million years.[36]

This also implies that the mean height of these continents would have been

about double what it is now three million and five million years ago

respectively: and as we have no reason to suppose this to have been the

case, we are led to infer the constant action of that upheaving force which

the presence of sedimentary formations even on the highest mountains also

demonstrates.

We have already discussed the unequal rate of denudation on hills, valleys,

and lowlands, in connection with the evidence of remote glacial epochs (p.

173); what we have now to consider is, what becomes of all this denuded

matter, and how far the known rate of denudation affords us a measure of

the rate of deposition, and thus gives us some indication of the lapse of

geological time from a comparison of this rate with the observed thickness

of stratified rocks on the earth's surface.

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\_How to Estimate the Thickness of the Sedimentary Rocks.\_--The sedimentary

rocks of which the earth's crust is mainly composed consist, according to

Sir Charles Lyell's classification, of fourteen great formations, of which

the most ancient is the Laurentian, and the most recent the Post-Tertiary

or Pleistocene; with thirty important subdivisions, each of which again

consists of a more or less considerable number of distinct beds or strata.

Thus, the Silurian formation is divided into Upper and Lower Silurian, each

characterized by a distinct set of fossil remains, and the Upper Silurian

again consists of a large number of separate beds, such as the Wenlock

Limestone, the Upper Llandovery Sandstone the Lower Llandovery Slates, &c.,

each usually characterised by a difference of mineral composition or

mechanical structure, as well as by some peculiar fossils. These beds and

formations vary greatly in extent, both above and beneath the surface, and

are also of very various thicknesses in different localities. A thick bed

or series of beds often thins out in a given direction, and sometimes

disappears altogether, so that two beds which were respectively above and

beneath it may come into contact. As an example of this thinning out,

American geologists adduce the PalÃ¦ozoic formations of the Appalachian

Mountains, which have a total thickness of 42,000 feet, but as they are

traced westward thin out till they become only 4,000 feet in total

thickness. In like manner the Carboniferous grits and shales are 18,000

feet thick in Yorkshire and Lancashire, but they thin out southwards, so

that in Leicestershire they are only 3,000 feet thick; and similar

phenomena occur in all strata and in every part of the world. It must be

observed that this thinning out has nothing to do with denudation (which

acts upon the surface of a country so as to produce great irregularities of

contour), but is a regular attenuation of the layers of rock, due to a

deficiency of sediment in certain directions at the original formation of

the deposit. Owing to this thinning out of stratified rocks, they are on

the whole of far less extent than is usually supposed. When we see a

geological map showing successive formations following each other in long

irregular belts across the country (as is well {107} seen in the case of

the Secondary rocks of England), and a corresponding section showing each

bed dipping beneath its predecessor, we are apt to imagine that beneath the

uppermost bed we should find all the others following in succession like

the coats of an onion. But this is far from being the case, and a

remarkable proof of the narrow limitation of these formations has been

recently obtained by a boring at Ware through the Chalk and Gault Clay,

which latter immediately rests on the Upper Silurian Wenlock Limestone full

of characteristic fossils, at a depth of only 800 feet. Here we have an

enormous gap, showing that none of earlier Secondary or late PalÃ¦ozoic

formations extend to this part of England, unless indeed they had been all

once elevated and entirely swept away by denudation.[37]

But if we consider how such deposits are now forming, we shall find that

the thinning out of the beds of each formation, and their restriction to

irregular bands and patches, is exactly what we should expect. The enormous

quantity of sediment continually poured into the sea by rivers, gradually

subsides to the bottom as soon as the motion of the water is checked. All

the heavier material must be deposited near the shore or in those areas

over which it is first spread by the tides or currents of the ocean; while

only the very fine mud and clay is carried out to considerable distances.

Thus all stratified deposits {108} will form most quickly near the shores,

and will thin out rapidly at greater distances, little or none being formed

in the depths of the great oceans. This important fact was demonstrated by

the specimens of sea-bottom examined during the voyage of the \_Challenger\_,

all the "shore deposits" being usually confined within a distance of 100 or

150 miles from the coast; while the "deep-sea deposits" are either purely

organic, being formed of the calcareous or siliceous skeletons of

globigerinÃ¦, radiolarians, and diatomaceÃ¦, or are clays formed of

undissolved portions of these, together with the disintegrated or dissolved

materials of pumice and volcanic dust, which being very light are carried

by wind or by water over the widest oceans.

From the preceding considerations we shall be better able to appreciate the

calculations as to the thickness of stratified deposits made by geologists.

Professor Ramsay has calculated that the sedimentary rocks of Britain alone

have a total \_maximum\_ thickness of 72,600 feet; while Professor Haughton,

from a survey of the whole world, estimates the \_maximum\_ thickness of the

known stratified rocks at 177,200 feet. Now these \_maximum\_ thicknesses of

each deposit will have been produced only where the conditions were

exceptionally favourable, either in deep water near the mouths of great

rivers, or in inland seas, or in places to which the drainage of extensive

countries was conveyed by ocean currents; and this great thickness will

necessarily be accompanied by a corresponding thinness, or complete absence

of deposit, elsewhere. How far the series of rocks found in any extensive

area, as Europe or North America, represents the whole series of deposits

which have been made there we cannot tell; but there is no reason to think

that it is a very inadequate representation of their \_maximum\_ thickness,

though it undoubtedly is of their \_extent\_ and \_bulk\_. When we see in how

many distinct localities patches of the same formation occur, it seems

improbable that the whole of the deposits formed during any one period

should have been destroyed, even in such an area as Europe, while it is

still more improbable that they should be so destroyed over the whole

world; and {109} if any considerable portion of them is left, that portion

may give a fair idea of their average, or even of their maximum, thickness.

In his admirable paper on "The Mean Thickness of the Sedimentary

Rocks,"[38] Dr. James Croll has dwelt on the extent of denudation in

diminishing the mean thickness of the rocks that have been formed,

remarking, "Whatever the present mean thickness of all the sedimentary

rocks of our globe may be, it must be small in comparison to the mean

thickness of all the sedimentary rocks which have been formed. This is

obvious from the fact that the sedimentary rocks of one age are partly

formed from the destruction of the sedimentary rocks of former ages. From

the Laurentian age down to the present day the stratified rocks have been

undergoing constant denudation." This is perfectly true, and yet the mean

thickness of that portion of the sedimentary rocks which remains may not be

very different from that of the entire mass, because denudation acts only

on those rocks which are exposed on the surface of a country, and most

largely on those that are upheaved; while, except in the rare case of an

extensive formation being \_quite horizontal\_, and wholly exposed to the sea

or to the atmosphere, denudation can have no tendency to diminish the

thickness of any entire deposit.[39] Unless, therefore, a formation is

completely destroyed by denudation in every part of the world (a thing very

improbable), we may have in existing rocks a not very inadequate

representation of the \_mean thickness\_ of all that have been formed, and

even of the \_maximum\_ thickness of the larger portion. This will be the

more likely because it is almost certain that many rocks contemporaneously

formed are counted by geologists as distinct formations, whenever they

differ in lithological character or in organic remains. But we know that

limestones, sandstones, and shales, are always forming at the same time;

{110} while a great difference in organic remains may arise from

comparatively slight changes of geographical features, or from difference

in the depth or purity of the water in which the animals lived.[40]

\_How to Estimate the Average Rate of Deposition of the Sedimentary

Rocks.\_--But if we take the estimate of Professor Haughton (177,200 feet),

which, as we have seen, is probably excessive, for the maximum thickness of

the sedimentary rocks of the globe of all known geological ages, can we

arrive at any estimate of the rate at which they were formed? Dr. Croll has

attempted to make such an estimate, but he has taken for his basis the

\_mean\_ thickness of the rocks, which we have no means whatever of arriving

at, and which he guesses, allowing for denudation, to be equal to the

\_maximum\_ thickness as measured by geologists. The land-area of the globe

is, according to Dr. Croll, 57,000,000[41] square miles, and he gives the

coast-line as 116,000 miles. This, however, is, for our purpose, rather too

much, as it allows for bays, inlets, and the smaller islands. An

approximate measurement on a globe shows that 100,000 miles will be nearer

the mark, and this has the advantage of being an easily remembered even

number. The distance from the coast, to which shore-deposits usually

extend, may be reckoned at about 100 or 150 miles, but by far the larger

portion of the matter brought down from the land will be deposited

comparatively close to the shore; that is, within twenty or thirty miles.

If we suppose the portion deposited beyond thirty miles to be added to the

deposits within that distance, and the whole reduced to a uniform thickness

in a direction at right angles to the coast, we should probably include all

areas where deposits of the maximum thickness {111} are forming at the

present time, along with a large but unknown proportion of surface where

the deposits were far below the maximum thickness. This follows, if we

consider that deposit must go on very unequally along different parts of a

coast, owing to the distance from each other of the mouths of great rivers

and the limitations of ocean currents; and because, compared with the areas

over which a thick deposit is forming annually, those where there is little

or none are probably at least twice as extensive. If, therefore, we take a

width of thirty miles along the whole coast-line of the globe as

representing the area over which deposits are forming, corresponding to the

maximum thickness as measured by geologists, we shall certainly over rather

than under-estimate the possible rate of deposit.[42]

Now a coast line of 100,000 miles with a width of 30 gives an area of

3,000,000 square miles, on which the denuded matter of the whole land-area

of 57,000,000 square {112} miles is deposited. As these two areas are as 1

to 19, it follows that deposition, as measured by \_maximum\_ thickness, goes

on at least nineteen times as fast as denudation--probably very much

faster. But the mean rate of denudation over the whole earth is about one

foot in three thousand years; therefore the rate of maximum deposition will

be at least 19 feet in the same time; and as the total maximum thickness of

all the stratified rocks of the globe is, according to Professor Haughton,

177,200 feet, the time required to produce this thickness of rock, at the

present rate of denudation and deposition, is only 28,000,000 years.[43]

\_The Rate of Geological Change Probably Greater in very Remote Times.\_--The

opinion that denudation and deposition went on more rapidly in earlier

times owing to the frequent occurrence of vast convulsions and cataclysms

was strenuously opposed by Sir Charles Lyell, who so well showed that

causes of the very same nature as those now in action were sufficient to

account for all the phenomena presented by the rocks throughout the whole

series of geological formations. But while upholding the soundness of the

views of the "uniformitarians" as opposed to the "convulsionists," we must

yet admit that there is reason for believing in a gradually increasing

intensity of all telluric action as we go back into past time. This subject

has been well treated by Mr. W. J. Sollas,[44] who shows that, if, as all

physicists maintain, the sun gave out perceptibly more heat in past ages

than now, this alone would cause an increase in almost all the forces that

have brought about geological phenomena. With greater heat there would be a

more extensive aqueous atmosphere, and, perhaps, a greater difference

between equatorial and polar temperatures; hence more violent winds,

heavier rains and snows, {113} and more powerful oceanic currents, all

producing more rapid denudation. At the same time, the internal heat of the

earth being greater, it would be cooling more rapidly, and thus the forces

of contraction--which cause the upheaving of mountains, the eruption of

volcanoes, and the subsidence of extensive areas--would be more powerful

and would still further aid the process of denudation. Yet again, the

earth's rotation was certainly more rapid in very remote times, and this

would cause more impetuous tides and still further add to the denuding

power of the ocean. It thus appears that, as we go back into the past,

\_all\_ the forces tending to the continued destruction and renewal of the

earth's surface would be in more powerful action, and must therefore tend

to reduce the time required for the deposition and upheaval of the various

geological formations. It may be true, as many geologists assert, that the

changes here indicated are so slow that they would produce comparatively

little effect within the time occupied by the known sedimentary rocks, yet,

whatever effect they did produce would certainly be in the direction here

indicated, and as several causes are acting together, their combined

effects may have been by no means unimportant. It must also be remembered

that such an increase of the primary forces on which all geologic change

depends would act with great effect in still further intensifying those

alternations of cold and warm periods in each hemisphere, or, more

frequently, of excessive and equable seasons, which have been shown to be

the result of astronomical, combined with geographical, revolutions; and

this would again increase the rapidity of denudation and deposition, and

thus still further reduce the time required for the production of the known

sedimentary rocks. It is evident therefore that these various

considerations all combine to prove that, in supposing that the rate of

denudation has been on the average only what it is now, we are almost

certainly over-estimating the \_time\_ required to have produced the whole

series of formations from the Cambrian upwards.

\_Value of the Preceding Estimate of Geological Time.\_--It is not of course

supposed that the calculation here given {114} makes any approach to

accuracy, but it is believed that it does indicate the \_order\_ of magnitude

of the time required. We have a certain number of data, which are not

guessed but the result of actual measurement; such are, the amount of solid

matter carried down by rivers, the width of the belt within which this

matter is mainly deposited, and the maximum thickness of the known

stratified rocks.[45] A considerable but unknown amount of denudation is

effected by the waves of the ocean eating away coast lines. This was once

thought to be of more importance than sub-aÃ«rial denudation, but it is now

believed to be comparatively slow in its action.[46] Whatever it may be,

however, it adds to the rate of formation of new strata, and its omission

from the calculation is again on the side of making the lapse of time

greater rather than less than the true amount. Even if a considerable

modification should be needed in some of the assumptions it has been

necessary to make, the result must still show that, so far as the time

required for the formation of the known stratified rocks, the hundred

million years allowed by physicists is not only ample, but will permit of

even more than an equal period anterior to the lowest Cambrian rocks, as

demanded by Mr. Darwin--a demand supported and enforced by the arguments,

taken from independent standpoints, of Professor Huxley and Professor

Ramsay.

\_Organic Modification Dependent on Change of Conditions.\_--Having {115}

thus shown that the physical changes of the earth's surface may have gone

on much more rapidly and occupied much less time than has generally been

supposed, we have now to inquire whether there are any considerations which

lead to the conclusion that organic changes may have gone on with

corresponding rapidity.

There is no part of the theory of natural selection which is more clear and

satisfactory than that which connects changes of specific forms with

changes of external conditions or environment. If the external world

remains for a moderate period unchanged, the organic world soon reaches a

state of equilibrium through the struggle for existence; each species

occupies its place in nature, and there is then no inherent tendency to

change. But almost any change whatever in the external world disturbs this

equilibrium, and may set in motion a whole series of organic revolutions

before it is restored. A change of climate in any direction will be sure to

injure some and benefit other species. The one will consequently diminish,

the other increase in number; and the former may even become extinct. But

the extinction of a species will certainly affect other species which it

either preyed upon, or competed with, or served for food; while the

increase of any one animal may soon lead to the extinction of some other to

which it was inimical. These changes will in their turn bring other

changes; and before an equilibrium is again established, the proportions,

ranges, and numbers, of the species inhabiting the country may be

materially altered. The complex manner in which animals are related to each

other is well exhibited by the importance of insects, which in many parts

of the world limit the numbers or determine the very existence of some of

the higher animals. Mr. Darwin says:--"Perhaps Paraguay offers the most

curious instance of this; for here neither cattle, nor horses, nor dogs

have ever run wild, though they swarm southward and northward in a wild

state; and Azara and Rengger have shown that this is caused by the greater

number in Paraguay of a certain fly, which lays its eggs in the navels of

these animals when first born. The increase of these flies, numerous as

they are, must be {116} habitually checked by some means, probably by other

parasitic insects. Hence, if certain insectivorous birds were to decrease

in Paraguay, the parasitic insects would probably increase; and this would

lessen the number of navel-frequenting flies--then cattle and horses would

run wild; and this would certainly alter (as indeed I have observed in

parts of South America) the vegetation: this again would largely affect the

insects, and this, as we have seen in Staffordshire, the insectivorous

birds, and so onwards in ever increasing circles of complexity."

Geographical changes would be still more important, and it is almost

impossible to exaggerate the modifications of the organic world that might

result from them. A subsidence of land separating a large island from a

continent would affect the animals and plants in a variety of ways. It

would at once modify the climate, and so produce a series of changes from

this cause alone; but more important would be its effect by isolating small

groups of individuals of many species and thus altering their relations to

the rest of the organic world. Many of these would at once be exterminated,

while others, being relieved from competition, might flourish and become

modified into new species. Even more striking would be the effects when two

continents, or any two land areas which had been long separated, were

united by an upheaval of the strait which divided them. Numbers of animals

would now be brought into competition for the first time. New enemies and

new competitors would appear in every part of the country; and a struggle

would commence which, after many fluctuations, would certainly result in

the extinction of some species, the modification of others, and a

considerable alteration in the proportionate numbers and the geographical

distribution of almost all.

Any other changes which led to the intermingling of species whose ranges

were usually separate would produce corresponding results. Thus, increased

severity of winter or summer temperature, causing southward migrations and

the crowding together of the productions of distinct regions, must

inevitably produce a struggle for existence, which would lead to many

changes both in the characters and {117} the distribution of animals. Slow

elevations of the land would produce another set of changes, by affording

an extended area in which the more dominant species might increase their

numbers; and by a greater range and variety of alpine climates and mountain

stations, affording room for the development of new forms of life.

\_Geographical Mutations as a Motive Power in Bringing about Organic

Changes.\_--Now, if we consider the various geographical changes which, as

we have seen, there is good reason to believe have ever been going on in

the world, we shall find that the motive power to initiate and urge on

organic changes has never been wanting. In the first place, every

continent, though permanent in a general sense, has been ever subject to

innumerable physical and geographical modifications. At one time the total

area has increased, and at another has diminished; great plateaus have

gradually risen up, and have been eaten out by denudation into mountain and

valley; volcanoes have burst forth, and, after accumulating vast masses of

eruptive matter, have sunk down beneath the ocean, to be covered up with

sedimentary rocks, and at a subsequent period again raised above the

surface; and the \_loci\_ of all these grand revolutions of the earth's

surface have changed their position age after age, so that each portion of

every continent has again and again been sunk under the ocean waves, formed

the bed of some inland sea, or risen high into plateaus and mountain

ranges. How great must have been the effects of such changes on every form

of organic life! And it is to such as these we may perhaps trace those

great changes of the animal world which have seemed to revolutionise it,

and have led us to class one geological period as the age of reptiles,

another as the age of fishes, and a third as the age of mammals.

But such changes as these must necessarily have led to repeated unions 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 {118} 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.

But the isolation of considerable masses of land for long periods also

afforded the means of preservation to many of the lower types, which thus

had time to become modified into a variety of distinct forms, some of which

became so well adapted to special modes of life that they have continued to

exist to the present day, thus affording us examples of the life of early

ages which would probably long since have become extinct had they been

always subject to the competition of the more highly organised animals. As

examples of such excessively archaic forms, we may mention the mud-fishes

and the ganoids, confined to limited fresh-water areas; the frogs and

toads, which still maintain themselves vigorously in competition with

higher forms; and among mammals the Ornithorhynchus and Echidna of

Australia; the whole order of Marsupials--which, out of Australia, where

they are quite free from competition, only exist abundantly in South

America, which was certainly long isolated from the northern continents;

the Insectivora, which, though widely scattered, are generally nocturnal or

subterranean in their habits; and the Lemurs, which are most abundant in

Madagascar, where they have long been isolated, and almost removed from the

competition of higher forms.

\_Climatal Revolutions as an Agent in Producing Organic Changes.\_--The

geographical and geological changes we have been considering are probably

those which have been most effective in bringing about the great features

of the distribution of animals, as well as the larger movements in the

development of organised beings; but it is to the alternations of warm and

cold, or of uniform and excessive climates--of almost perpetual spring in

arctic as well as in temperate lands, with occasional phases of cold

culminating at remote intervals in glacial epochs,--that we must impute

some of the more remarkable changes both in the specific characters and in

the distribution of organisms.[47] {119} Although the geological evidence

is opposed to the belief in early glacial epochs except at very remote and

distant intervals, there is nothing which contradicts the occurrence of

repeated changes of climate, which, though too small in amount to produce

any well-marked physical or organic change, would yet be amply sufficient

to keep the organic world in a constant state of movement, and which, by

subjecting the whole flora and fauna of a country at comparatively short

intervals to decided changes of physical conditions, would supply that

stimulus and motive power which, as we have seen, is all that is necessary

to keep the processes of "natural selection" in constant operation.

The frequent recurrence of periods of high and of low excentricity must

certainly have produced changes of climate of considerable importance to

the life of animals and plants. During periods of high excentricity with

summer in \_perihelion\_, that season would be certainly very much hotter,

while the winters would be longer and colder than at present; and although

geographical conditions might prevent any permanent increase of snow and

ice even in the extreme north, yet we cannot doubt that the whole northern

hemisphere would then have a very different climate than when the changing

phase of precession brought a very cool summer and a very mild winter--a

perpetual spring, in fact. Now, such a change of climate would certainly be

calculated to bring about a considerable change of \_species\_, both by

modification and migration, without any such decided change of \_type\_

either in the vegetation or the animals that we could say from their fossil

remains that any change of climate had taken place. Let us suppose, for

instance, that the climate of England and that of Canada were to be

mutually exchanged, and that the change took five or six thousand years to

bring about, it cannot be doubted that considerable modifications in the

fauna and flora of both countries would be the result, although it is

impossible to predict {120} what the precise changes would be. We can

safely say, however, that some species would stand the change better than

others, while it is highly probable that some would be actually benefited

by it, and that others would be injured. But the benefited would certainly

increase, and the injured decrease, in consequence, and thus a series of

changes would be initiated that might lead to most important results.

Again, we are sure that some species would become modified in adaptation to

the change of climate more readily than others, and these modified species

would therefore increase at the expense of others not so readily modified;

and hence would arise on the one hand extinction of species, and on the

other the production of new forms.

But this is the very least amount of change of climate that would certainly

occur every 10,500 years when there was a high excentricity, for it is

impossible to doubt that a varying distance of the sun in summer from 86 to

99 millions of miles (which is what occurred during--as supposed--the

Miocene period, 850,000 years ago) would produce an important difference in

the summer temperature and in the actinic influence of sunshine on

vegetation. For the intensity of the sun's rays would vary as the square of

the distance, or nearly as 74 to 98, so that the earth would be actually

receiving one-fourth less sun-heat during summer at one time than at the

other. An equally high excentricity occurred 2,500,000 years back, and no

doubt was often reached during still earlier epochs, while a lower but

still very high excentricity has frequently prevailed, and is probably near

its average value. Changes of climate, therefore, every 10,500 years, of

the character above indicated and of varying intensity, have been the rule

rather than the exception in past time; and these changes must have been

variously modified by changing geographical conditions so as to produce

climatic alterations in different directions, giving to the ancient lands

either dry or wet seasons, storms or calms, equable or excessive

temperatures, in a variety of combinations of which the earth perhaps

affords no example under the present low phase of {121} excentricity and

consequent slight inequality of sun-heat.

\_Present Condition of the Earth One of Exceptional Stability as Regards

Climate.\_--It will be seen, by a reference to the diagram at page 171, that

during the last three million years the excentricity has been \_less\_ than

it is now on eight occasions, for short periods only, making up a total of

about 280,000 years; while it has been \_more\_ than it is now for many long

periods, of from 300,000 to 700,000 years each, making a total of 2,720,000

years; or nearly as 10 to 1. For nearly half the entire period, or

1,400,000 years, the excentricity has been nearly double what it is now,

and this is not far from its mean condition. We have no reason for

supposing that this long period of three million years, for which we have

tables, was in any way exceptional as regards the degree or variation of

excentricity; but, on the contrary, we may pretty safely assume that its

variations during this time fairly represent its average state of increase

and decrease during all known geological time. But when the glacial epoch

ended, 72,000 years ago, the excentricity was about double its present

amount; it then rapidly decreased till, at 60,000 years back, it was very

little greater than it is now, and since then it has been uniformly small.

It follows that, for about 60,000 years before our time, the mutations of

climate every 10,500 years have been comparatively unimportant, and that

the temperate zones have enjoyed \_an exceptional stability of climate\_.

During this time those powerful causes of organic change which depend on

considerable changes of climate and the consequent modifications,

migrations, and extinctions of species, will not have been at work; the

slight changes that did occur would probably be so slow and so little

marked that the various species would be able to adapt themselves to them

without much disturbance; and the result would be \_an epoch of exceptional

stability of species\_.

But it is from this very period of \_exceptional stability\_ that we obtain

our only \_scale\_ for measuring the rate of organic change. It includes not

only the historical period, {122} but that of the Swiss Lake dwellings, the

Danish shell-mounds, our peat-bogs, our sunken forests, and many of our

superficial alluvial deposits--the whole in fact, of the iron, bronze, and

neolithic ages. Even some portion of the palÃ¦olithic age, and of the more

recent gravels and cave-earths may come into the same general period if

they were formed when the glacial epoch was passing away. Now throughout

all these ages we find no indication of change of species, and but little,

comparatively, of migration. We thus get an erroneous idea of \_the

permanence and stability of specific forms\_, due to the period immediately

antecedent to our own being a \_period of exceptional permanence and

stability\_ as regards climatic and geographical conditions.[48]

\_Date of Last Glacial Epoch and its Bearing on the Measurement of

Geological Time.\_--Directly we go back from this stable period we come upon

changes both in the forms and in the distribution of species; and when we

pass beyond the last glacial epoch into the Pliocene period we find

ourselves in a comparatively new world, surrounded by a considerable number

of species altogether different from any which now exist, together with

many others which, though still living, now inhabit distant regions. It

seems not improbable that what is termed the Pliocene period, was really

the coming on of the glacial epoch, and this is the opinion of Professor

Jules Marcou.[49] According to our views, a considerable amount of

geographical change must have occurred at the change from the Miocene to

the Pliocene, favouring the refrigeration of the northern hemisphere, and

leading, in the way already pointed out, to the glacial epoch whenever a

high degree of excentricity {123} prevailed. As many reasons combine to

make us fix the height of the glacial epoch at the period of high

excentricity which occurred 200,000 years back, and as the Pliocene period

was probably not of long duration, we must suppose the next great phase of

very high excentricity (850,000 years ago) to fall within the Miocene

epoch. Dr. Croll believes that this must have produced a glacial period,

but we have shown strong reasons for believing that, in concurrence with

favourable geographical conditions, it led to uninterrupted warm climates

in the temperate and northern zones. This, however, did not prevent the

occurrence of local glaciation wherever other conditions led to its

initiation, and the most powerful of such conditions is a great extent of

high land. Now we know that the Alps acquired a considerable part of their

elevation during the latter part of the Miocene period, since Miocene rocks

occur at an elevation of over 6,000 feet, while Eocene beds occur at nearly

10,000 feet. But since that time there has been a vast amount of

denudation, so that these rocks may have been at first raised much higher

than we now find them, and thus a considerable portion of the Alps may have

been more elevated than they are now. This would certainly lead to an

enormous accumulation of snow, which would be increased when the

excentricity reached a maximum, as already fully explained, and may then

have caused glaciers to descend into the adjacent sea, carrying those

enormous masses of rock which are buried in the Upper Miocene of the

Superga in Northern Italy. 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. This is quite in

harmony with the indications of an uninterrupted warm climate and rich

vegetation during the very same period in the adjacent low countries, just

as we find at the present day in New Zealand a delightful climate and a

rich vegetation of Metrosideros, {124} fuchsias and tree-ferns on the very

borders of huge glaciers, descending to within 700 feet of the sea-level.

It is not pretended that these estimates of geological time have any more

value than probable guesses; but it is certainly a curious coincidence that

two remarkable periods of high excentricity should have occurred, at such

periods and at such intervals apart, as very well accord with the

comparative remoteness of the two deposits in which undoubted signs of

ice-action have been found, and that both these are localised in the

vicinity of mountains which are known to have acquired a considerable

elevation at about the same period of time.

In the tenth edition of the \_Principles of Geology\_, Sir Charles Lyell,

taking the amount of change in the species of mollusca as a guide,

estimated the time elapsed since the commencement of the Miocene as

one-third that of the whole Tertiary epoch, and the latter at one-fourth

that of geological time since the Cambrian period. Professor Dana, on the

other hand, estimates the Tertiary as only one-fifteenth of the Mesozoic

and PalÃ¦ozoic combined. On the estimate above given, founded on the dates

of phases of high excentricity, we shall arrive at about four million years

for the Tertiary epoch, and sixteen million years for the time elapsed

since the Cambrian, according to Lyell, or sixty millions according to

Dana. The estimate arrived at from the rate of denudation and deposition

(twenty-eight million years) is nearly midway between these, and it is, at

all events, satisfactory that the various measures result in figures of the

same order of magnitude, which is all one can expect when discussing so

difficult and exceedingly speculative a subject.

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 {125} far more extensive period which

includes all possibility of life upon the earth.

\_Concluding Remarks.\_--In the present chapter I have endeavoured to show

that, combining the measured rate of denudation with the estimated

thickness and probable extent of the known series of sedimentary rocks, we

may arrive at a rude estimate of the time occupied in the formation of

those rocks. From another point of departure--that of the probable date of

the Miocene period, as determined by the epoch of high excentricity

supposed to have aided in the production of the Alpine glaciation during

that period, and taking the estimate of geologists as to the proportionate

amount of change in the animal world since that epoch--we obtain another

estimate of the duration of geological time, which, though founded on far

less secure data, agrees pretty nearly with the former estimate. The time

thus arrived at is immensely less than the usual estimates of geologists,

and is so far within the limits of the duration of the earth as calculated

by Sir William Thomson, as to allow for the development of the lower

organisms an amount of time anterior to the Cambrian period several times

greater than has elapsed between that period and the present day. I have

further shown that, in the continued mutations of climate produced by high

excentricity and opposite phases of precession, even though these did not

lead to glacial epochs, we have a motive power well calculated to produce

far more rapid organic changes than have hitherto been thought possible;

while in the enormous amount of specific variation (as demonstrated in an

earlier chapter), we have ample material for that power to act upon, so as

to keep the organic world in a state of rapid change and development

proportioned to the comparatively rapid changes in the earth's surface.

We have now finished the series of preliminary studies of the biological

conditions and physical changes which have affected the modification and

dispersal of organisms, and have thus brought about their actual

distribution on {126} the surface of the earth. These studies will, it is

believed, place us in a condition to solve most of the problems presented

by the distribution of animals and plants, whenever the necessary facts,

both as to their distribution and their affinities, are sufficiently well

known; and we now proceed to apply the principles we have established to

the interpretation of the phenomena presented by some of the more important

and best known of the islands of our globe, limiting ourselves to these for

reasons which have been already sufficiently explained in our preface.

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PART II

\_INSULAR FAUNAS AND FLORAS\_

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CHAPTER XI

THE CLASSIFICATION OF ISLANDS

Importance of Islands in the Study of the Distribution of

Organisms--Classification of Islands with Reference to

Distribution--Continental Islands--Oceanic Islands.

In the preceding chapters, forming the first part of our work, we have

discussed, more or less fully, the general features presented by animal

distribution, as well as the various physical and biological changes which

have been the most important agents in bringing about the present condition

of the organic world.

We now proceed to apply these principles to the solution of the numerous

problems presented by the distribution of animals; and in order to limit

the field of our inquiry, and at the same time to deal only with such facts

as may be rendered intelligible and interesting to those readers who have

not much acquaintance with the details of natural history, we propose to

consider only such phenomena as are presented by the islands of the globe.

\_Importance of Islands in the Study of the Distribution of

Organisms.\_--Islands possess many advantages for the study of the laws and

phenomena of distribution. As compared with continents they have a

restricted area and definite boundaries, and in most cases their

geographical and biological limits coincide. The number of species and of

genera they contain is always much smaller than in the {242} case of

continents, and their peculiar species and groups are usually well defined

and strictly limited in range. Again, their relations with other lands are

often direct and simple, and even when more complex are far easier to

comprehend than those of continents; and they exhibit besides certain

influences on the forms of life and certain peculiarities in their

distribution which continents do not present, and whose study offers many

points of interest.

In islands we have the facts of distribution presented to us, sometimes in

their simplest forms, in other cases becoming gradually more and more

complex; and we are therefore able to proceed step by step in the solution

of the problems they present. But as in studying these problems we have

necessarily to take into account the relations of the insular and

continental faunas, we also get some knowledge of the latter, and acquire

besides so much command over the general principles which underlie all

problems of distribution, that it is not too much to say that when we have

mastered the difficulties presented by the peculiarities of island life we

shall find it comparatively easy to deal with the more complex and less

clearly defined problems of continental distribution.

\_Classification of Islands with Reference to Distribution.\_--Islands have

had two distinct modes of origin--they have either been separated from

continents of which they are but detached fragments, or they have

originated in the ocean and have never formed part of a continent or any

large mass of land. This difference of origin is fundamental, and leads to

a most important difference in their animal inhabitants; and we may

therefore first distinguish the two classes--oceanic and continental

islands.

Mr. Darwin appears to have been the first writer who called attention to

the number and importance, both from a geological and biological point of

view, of oceanic islands. He showed that with very few exceptions all the

remoter islands of the great oceans were of volcanic or coralline

formation, and that none of them contained indigenous mammalia or amphibia.

He also showed the connection of these two phenomena, and maintained that

none of the islands so characterised had ever formed {243} part of a

continent. This was quite opposed to the opinions of the scientific men of

the day, who almost all held the idea of continental extensions, and of

oceanic islands being their fragments, and it was long before Mr. Darwin's

views obtained general acceptance. Even now the belief still lingers; and

we continually hear of old Atlantic or Pacific continents, of "Atlantis" or

"Lemuria," of which hypothetical lands many existing islands, although

wholly volcanic, are thought to be the remnants. We have already seen that

Darwin connected the peculiar geological structure of oceanic islands with

the permanence of the great oceans which contain them, and we have shown

that several distinct lines of evidence all point to the same conclusion.

We may therefore define oceanic islands, as follows:--Islands of volcanic

or coralline formation, usually far from continents and always separated

from them by very deep sea, entirely without indigenous land mammalia or

amphibia, but with a fair number of birds and insects, and usually with

some reptiles. This definition will exclude only two islands which have

been sometimes classed as oceanic--New Zealand and the Seychelles.

Rodriguez, which was once thought to be another exception, has been shown

by the explorations during the Transit of Venus Expedition to be

essentially volcanic, with some upraised coralline limestone.

\_Continental Islands.\_--Continental islands are always more varied in their

geological formation, containing both ancient and recent stratified rocks.

They are rarely very remote from a continent, and they always contain some

land mammals and amphibia, as well as representatives of the other classes

and orders in considerable variety. They may, however, be divided into two

well-marked groups--ancient and recent continental islands--the characters

of which may be easily defined.

Recent continental islands are always situated on submerged banks

connecting them with a continent, and the depth of the intervening sea

rarely exceeds 100 fathoms. They resemble the continent in their geological

structure, while their animal and vegetable productions are either almost

identical with those of the continent, or if {244} otherwise, the

difference consists in the presence of closely allied species of the same

types, with occasionally a very few peculiar genera. They possess in fact

all the characteristics of a portion of the continent, separated from it at

a recent geological period.

Ancient continental islands differ greatly from the preceding in many

respects. They are not united to the adjacent continent by a shallow bank,

but are usually separated from it by a depth of sea of several hundreds to

more than a thousand fathoms. In geological structure they agree generally

with the more recent islands; like them they possess mammalia and amphibia,

usually in considerable abundance, as well as all other classes of animals;

but these are highly peculiar, almost all being distinct species, and many

forming distinct and peculiar genera or families. They are also well

characterised by the fragmentary nature of their fauna, many of the most

characteristic continental orders or families being quite unrepresented,

while some of their animals are allied, not to such forms as inhabit the

adjacent continent, but to others found only in remote parts of the world.

This very remarkable set of characters marks off the islands which exhibit

them as a distinct class, which often present the greatest anomalies and

most difficult problems to the student of distribution.

\_Oceanic Islands.\_--The total absence of warm-blooded terrestrial animals

in an island otherwise well suited to maintain them, is held to prove that

such island is no mere fragment of any existing or submerged continent, but

one that has been actually produced in mid-ocean. It is true that if a

continental island were to be completely submerged for a single day and

then again elevated, its higher terrestrial animals would be all destroyed,

and if it were situated at a considerable distance from land it would be

reduced to the same zoological condition as an oceanic island. But such a

complete submergence and re-elevation appears never to have taken place,

for there is no single island on the globe which has the physical and

geological features of a continental, combined with the zoological features

of an oceanic island. It is true that some of the coral-islands may be

formed upon submerged lands {245} of a continental character, but we have

no proof of this; and even if it were so, the existing islands are to all

intents and purposes oceanic.

We will now pass on to a consideration of some of the more interesting

examples of these three classes, beginning with oceanic islands.

All the animals which now inhabit such oceanic islands must either

themselves have reached them by crossing the ocean, or be the descendants

of ancestors who did so. Let us then see what are, in fact, the animal and

vegetable inhabitants of these islands, and how far their presence can be

accounted for. We will begin with the Azores, or Western Islands, because

they have been thoroughly well explored by naturalists, and in their

peculiarities afford us an important clue to some of the most efficient

means of distribution among several classes of animals.

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CHAPTER XII

OCEANIC ISLANDS:--THE AZORES AND BERMUDA

THE AZORES, OR WESTERN ISLANDS

Position and Physical Features--Chief Zoological Features of the

Azores--Birds--Origin of the Azorean Bird Fauna--Insects of the

Azores--Land-Shells of the Azores--The Flora of the Azores--The

Dispersal of Seeds--Birds as Seed-Carriers--Facilities for Dispersal of

Azorean Plants--Important Deduction from the Peculiarities of the

Azorean Fauna and Flora.

BERMUDA

Position and Physical Features--The Red Clay of Bermuda--Zoology of

Bermuda--Birds of Bermuda--Comparison of the Bird Faunas of Bermuda and

the Azores--Insects of Bermuda--Land Mollusca--Flora of

Bermuda--Concluding Remarks on the Azores and Bermuda.

We will commence our investigation into the phenomena presented by oceanic

islands, with two groups of the North Atlantic, in which the facts are of a

comparatively simple nature and such as to afford us a valuable clue to a

solution of the more difficult problems we shall have to deal with further

on. The Azores and Bermuda offer great contrasts in physical features, but

striking similarities in geographical position. The one is volcanic, the

other coralline; but both are surrounded by a wide expanse of ocean of

enormous depth, the one being about as far from Europe as the other is from

America. Both are situated in the {247} temperate zone, and they differ

less than six degrees in latitude, yet the vegetation of the one is wholly

temperate, while that of the other is almost tropical. The productions of

the one are related to Europe, as those of the other are to America, but

they present instructive differences; and both afford evidence of the

highest value as to the means of dispersal of various groups of organisms

across a wide expanse of ocean.

THE AZORES, OR WESTERN ISLANDS.

These islands, nine in number, form a widely scattered group, situated

between 37Â° and 39Â° 40' N. Lat. and stretching in a south-east and

north-west direction over a distance of nearly 400 miles. The largest of

the islands, San Miguel, is about forty miles long, and is one of the

nearest to Europe, being rather under 900 miles from the coast of Portugal,

from which it is separated by an ocean 2,500 fathoms deep. The depth

between the islands does not seem to be known, but the 1,000 fathom line

encloses the whole group pretty closely, while a depth of about 1,800

fathoms is reached within 300 miles in all directions. These great depths

render it in the highest degree improbable that the Azores have ever been

united with the European continent; while their being wholly volcanic is

equally opposed to the view of their having formed part of an extensive

Atlantis including Madeira and the Canaries. The only exception to their

volcanic structure is the occurrence in one small island only (Santa Maria)

of some marine deposits of Upper Miocene age--a fact which proves some

alterations of level, and perhaps a greater extension of this island at

some former period, but in no way indicates a former union of the islands,

or any greater extension of the whole group. It proves, however, that the

group is of considerable antiquity, since it must date back to Miocene

times; and this fact may be of importance in considering the origin and

peculiar features of the fauna and flora. It thus appears that in all

physical features the Azores correspond strictly with our physical

definition of "oceanic islands," while their great distance {248} from any

other land, and the depth of the ocean around them, make them typical

examples of the class. We should therefore expect them to be equally

typical in their fauna and flora; and this is the case as regards the most

important characteristics, although in some points of detail they present

exceptional phenomena.

[Illustration: OUTLINE MAP OF THE AZORES.]

NOTE.--

The light tint shows where the sea is less than 1,000 fathoms deep.

The dark tint " " " more than 1,000 fathoms deep.

The figures show depths in fathoms.

\_Chief Zoological Features of the Azores.\_[50]--The great feature of

oceanic islands--the absence of all indigenous land-mammalia and

amphibia--is well shown in this {249} group; and it is even carried

further, so as to include all terrestrial vertebrata, there being no snake,

lizard, frog, or fresh-water fish, although the islands are sufficiently

extensive, possess a mild and equable climate, and are in every way adapted

to support all these groups. On the other hand, flying creatures, as birds

and insects, are abundant; and there is also one flying mammal--a small

European bat. It is true that rabbits, weasels, rats and mice, and a small

lizard peculiar to Madeira and Teneriffe, are now found wild in the Azores,

but there is good reason to believe that these have all been introduced by

human agency. The same may be said of the gold-fish and eels now found in

some of the lakes, there being not a single fresh-water fish which is truly

indigenous to the islands. When we consider that the nearest part of the

group is about 900 miles from Portugal, and more than 550 miles from

Madeira, it is not surprising that none of these terrestrial animals can

have passed over such a wide expanse of ocean unassisted by man.

Let us now see what animals are believed to have reached the group by

natural means, and thus constitute its indigenous fauna. These consist of

birds, insects, and land-shells, each of which must be considered

separately.

\_Birds.\_--Fifty-three species of birds have been observed at the Azores,

but the larger proportion (thirty-one) are either aquatic or waders--birds

of great powers of flight, whose presence in the remotest islands is by no

means remarkable. Of these two groups twenty are residents, breeding in the

islands, while eleven are stragglers only visiting the islands

occasionally, and all are common European species. The land-birds,

twenty-two in number, are more interesting, four only being stragglers,

while eighteen are permanent residents. The following is a list of these

resident land-birds:--

1. Common Buzzard (\_Buteo vulgaris\_)

2. Long-eared Owl (\_Asio otus\_)

3. Barn Owl (\_Strix flammea\_)

4. Blackbird (\_Turdus merula\_)

5. Robin (\_Erythacus rubecula\_)

6. Blackcap (\_Sylvia atricapilla\_)

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7. Gold-crest (\_Regulus cristatus\_)

8. Wheatear (\_Saxicola oenanthe\_)

9. Grey Wagtail (\_Motacilla sulphurea\_)

10. Atlantic Chaffinch (\_Fringilla tintillon\_)

11. Azorean Bullfinch (\_Pyrrhula murina\_)

12. Canary (\_Serinus canarius\_)

13. Common Starling (\_Sturnus vulgaris\_)

14. Lesser Spotted Woodpecker (\_Dryobates minor\_)

15. Wood-pigeon (\_Columba palumbus\_)

16. Rock Dove (\_Columba livia\_)

17. Red-legged Partridge (\_Caccabis rufa\_)

18. Common Quail (\_Coturnix communis\_)

All the above-named birds are common in Europe and North Africa except

three--the Atlantic chaffinch and the canary which inhabit Madeira and the

Canary Islands, and the Azorean bullfinch, which is peculiar to the islands

we are considering.

\_Origin of the Azorean Bird-fauna.\_--The questions we have now before us

are--how did these eighteen species of birds first reach the Azores, and

how are we to explain the presence of a single peculiar species while all

the rest are identical with European birds? In order to answer them, let us

first see what stragglers now actually visit the Azores from the nearest

continents. The four species given in Mr. Godman's list are the kestrel,

the oriole, the snow-bunting, and the hoopoe; but he also tells us that

there are certainly others, and adds: "Scarcely a storm occurs in spring or

autumn without bringing one or more species foreign to the islands; and I

have frequently been told that swallows, larks, grebes, and other species

not referred to here, are not uncommonly seen at those seasons of the

year."

We have, therefore, every reason to believe that the birds which are now

residents originated as stragglers, which occasionally found a haven in

these remote islands when driven out to sea by storms. Some of them, no

doubt, still often arrive from the continent, but these cannot easily be

distinguished as new arrivals among those which are permanent inhabitants.

Many facts mentioned by Mr. Godman show that this is the case. A barn-owl,

much exhausted, flew on board a whaling-ship when 500 miles S.W. of the

Azores; and even if it had come from {251} Madeira it must have travelled

quite as far as from Portugal to the islands. Mr. Godman also shot a single

specimen of the wheatear in Flores after a strong gale of wind, and as no

one on the island knew the bird, it was almost certainly a recent arrival.

Subsequently a few were found breeding in the old crater of Corvo, a small

adjacent island; and as the species is not found in any other island of the

group, we may infer that this bird is a recent immigrant in process of

establishing itself.

Another fact which is almost conclusive in favour of the bird-population

having arrived as stragglers is, that they are most abundant in the islands

nearest to Europe and Africa. The Azores consist of three divisions--an

eastern, consisting of two islands, St. Michael's and St. Mary's; a central

of five, Terceira, Graciosa, St. George's, Pico, and Fayal; and a western

of two, Flores and Corvo. Now had the whole group once been united to the

continent, or even formed parts of one extensive Atlantic island, we should

certainly expect the central group, which is more compact and has a much

larger area than all the rest, to have the greatest number and variety of

birds. But the fact that birds are most numerous in the eastern group, and

diminish as we go westward, is entirely opposed to this theory, while it is

strictly in accordance with the view that they are all stragglers from

Europe, Africa, or the other Atlantic islands. Omitting oceanic wanderers,

and including all birds which have probably arrived involuntarily, the

numbers are found to be forty species in the eastern group, thirty-six in

the central, and twenty-nine in the western.

To account for the presence of one peculiar species--the bullfinch (which,

however, does not differ from the common European bullfinch more than do

some of the varieties of North American birds from their type-species) is

not difficult; the wonder rather being that there are not more peculiar

forms. In our third chapter we have seen how great is the amount of

individual variation in birds, and how readily local varieties become

established wherever the physical conditions are sufficiently distinct. Now

we can hardly have a greater difference of conditions {252} than between

the continent of Europe or North Africa, and a group of rocky islands in

mid-Atlantic, situated in the full course of the Gulf Stream and with an

excessively mild though stormy climate. We have every reason to believe

that special modifications would soon become established in any animals

completely isolated under such conditions. But they are not, as a rule,

thus completely isolated, because, as we have seen, stragglers arrive at

short intervals; and these, mixing with the residents, keep up the purity

of the breed. It follows, that only those species which reach the Azores at

very remote intervals will be likely to acquire well-marked distinctive

characters; and this appears to have happened with the bullfinch alone, a

bird which does not migrate, and is therefore less likely to be blown out

to sea, more especially as it inhabits woody districts. A few other Azorean

birds, however, exhibit slight differences from their European allies.

There is another reason for the very slight amount of peculiarity presented

by the fauna of the Azores as compared with many other oceanic islands,

dependent on its comparatively recent origin. The islands themselves may be

of considerable antiquity, since a few small deposits, believed to be of

Miocene age, have been found on them, but there can be little doubt that

their present fauna, at all events as concerns the birds, had its origin

since the date of the last glacial epoch. Even now icebergs reach the

latitude of the Azores but a little to the west of them; and when we

consider the proofs of extensive ice-action in North America and Europe, we

can hardly doubt that these islands were at that time surrounded with

pack-ice, while their own mountains, reaching 7,600 feet high in Pico,

would almost certainly have been covered with perpetual snow and have sent

down glaciers to the sea. They might then have had a climate almost as bad

as that now endured by the Prince Edward Islands in the southern

hemisphere, nearly ten degrees farther from the equator, where there are no

land-birds whatever, although the distance from Africa is not much greater

than that of the Azores from Europe, while the vegetation is limited to a

few alpine plants and mosses. This recent origin of the {253} birds

accounts in a great measure for their identity with those of Europe,

because, whatever change has occurred must have been effected in the

islands themselves, and in a time limited to that which has elapsed since

the glacial epoch passed away.

\_Insects of the Azores.\_--Having thus found no difficulty in accounting for

the peculiarities presented by the birds of these islands, we have only to

see how far the same general principles will apply to the insects and

land-shells. The butterflies, moths, and hymenoptera, are few in number,

and almost all seem to be common European species, whose presence is

explained by the same causes as those which have introduced the birds.

Beetles, however, are more numerous, and have been better studied, and

these present some features of interest. The total number of species yet

known is 212, of which 175 are European; but out of these 101 are believed

to have been introduced by human agency, leaving seventy-four really

indigenous. Twenty-three of these indigenous species are not found in any

of the other Atlantic islands, showing that they have been introduced

directly from Europe by causes which have acted more powerfully here than

farther south. Besides these there are thirty-six species not found in

Europe, of which nineteen are natives of Madeira or the Canaries, three are

American, and fourteen are altogether peculiar to the Azores. These latter

are mostly allied to species found in Europe or in the other Atlantic

islands, while one is allied to an American species, and two are so

distinct as to constitute new genera. The following list of these peculiar

species will be interesting:--

CARABIDÃ.

\_Anchomenus aptinoides\_ Allied to a species from the Canaries.

\_Bembidium hesperus\_ Allied to the European \_B. lÃ¦tum\_.

DYTISCIDÃ.

\_Agabus godmanni\_ Allied to the European \_A. dispar\_.

COLYDIIDÃ.

\_Tarphius wollastoni\_ A genus almost peculiar to the Atlantic

islands.

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ELATERIDÃ.

\_Heteroderes azoricus\_ Allied to a Brazilian species.

\_Elastrus dolosus\_ Belongs to a peculiar Madagascar genus!

MELYRIDÃ.

\_Attalus miniaticollis\_ Allied to a Canarian species.

RHYNCOPHORA.

\_PhlÃ¦ophagus variabilis\_ Allied to European and Atlantic species.

\_Acalles droueti\_ A Mediterranean and Atlantic genus.

\_Laparocerus azoricus\_ Allied to Madeiran species.

\_Asynonychun godmansi\_ A peculiar genus, allied to \_Brachyderes\_, of

the south of Europe.

\_Neocnemis occidentalis\_ A peculiar genus, allied to the European

genus \_Strophosomus\_.

HETEROMERA.

\_Helops azoricus\_ Allied to \_H. vulcanus\_ of Madeira.

STAPHYLINIDÃ.

\_Xenomma melanocephala\_ Allied to \_X. filiforme\_ from the Canaries.

This greater amount of speciality in the beetles than in the birds may be

due to two causes. In the first place many of these small insects have no

doubt survived the glacial epoch, and may, in that case, represent very

ancient forms which have become extinct in their native country; and in the

second place, insects have many more chances of reaching remote islands

than birds, for not only may they be carried by gales of wind, but

sometimes, in the egg or larva state or even as perfect insects, they may

be drifted safely for weeks over the ocean, buried in the light stems of

plants or in the solid wood of trees in which many of them undergo their

transformations. Thus we may explain the presence of three common South

American species (two elaters and a longicorn), all wood-eaters, and

therefore liable to be occasionally brought in floating timber by the Gulf

Stream. But insects are also immensely more numerous in species than are

land-birds, and their transmission would be in most cases quite

involuntary, and not dependent on their own powers of flight as with birds;

and thus the chances against the same species being frequently carried to

the same island would be considerable. If we add to this the dependence of

so {255} many insects on local conditions of climate and vegetation, and

their liability to be destroyed by insectivorous birds, we shall see that,

although there may be a greater probability of insects as a whole reaching

the islands, the chance against any particular species arriving there, or

against the same species arriving frequently, is much greater than in the

case of birds. The result is, that (as compared with Britain for example)

the birds are, proportionately, much more numerous than the beetles, while

the peculiar species of beetles are much more numerous than among birds,

both facts being quite in accordance with what we know of the habits of the

two groups. We may also remark, that the small size and obscure characters

of many of the beetles renders it probable that species now supposed to be

peculiar, really inhabit some parts of Europe or North Africa.

It is interesting to note that the two families which are pre-eminently

wood, root, or seed eaters, are those which present the greatest amount of

speciality. The two ElateridÃ¦ alone exhibit remote affinities, the one with

a Brazilian the other with a Madagascar group; while the only peculiar

genera belong to the Rhyncophora, but are allied to European forms. These

last almost certainly form a portion of the more ancient fauna of the

islands which migrated to them in pre-glacial times, while the Brazilian

elater appears to be the solitary example of a living insect brought by the

Gulf Stream to these remote shores. The elater, having its nearest living

ally in Madagascar (\_Elastrus dolosus\_), cannot be held to indicate any

independent communication between these distant islands; but is more

probably a relic of a once more widespread type which has only been able to

maintain itself in these localities. Mr. Crotch states that there are some

\_species\_ of beetles common to Madagascar and the Canary Islands, while

there are several \_genera\_, common to Madagascar and South America, and

some to Madagascar and Australia. The clue to these apparent anomalies is

found in other genera being common to Madagascar, Africa, and South

America, while others are Asiatic or Australian. Madagascar, in fact, has

insect relations with every part of {256} the globe, and the only rational

explanation of such facts is, that they are indications of very ancient and

once widespread groups, maintaining themselves only in a few widely

separated portions of what was at one time or another the area of their

distribution.

\_Land-shells of the Azores.\_--Like the insects and birds, the land-shells

of these islands have a generally European aspect, but with a larger

proportion of peculiar species. This was to be expected, because the means

by which molluscs are carried over the sea are far less numerous and varied

than in the case of insects;[51] and we may therefore conclude that their

introduction is a very rare event, and that a species once arrived remains

for long periods undisturbed by new arrivals, and is therefore more likely

to become modified by the new conditions, and then fixed as a distinct

type. Out of the sixty-nine known species, thirty-seven are common to

Europe or the other Atlantic islands, while thirty-two are peculiar, though

almost all are distinctly allied to European types. The majority of these

shells, especially the peculiar forms, are very small, and many of them may

date back to beyond the glacial epoch. The eggs of these would be

exceedingly minute, and might occasionally be carried on leaves or other

materials during gales of exceptional violence and duration, while others

might be conveyed with the earth that often sticks to the feet of birds.

There are also, probably, other unknown means of conveyance; but however

this may be, the general character of the land-molluscs is such as to

confirm the conclusions we have arrived at from a study of the birds and

insects,--that these islands have never been connected with a continent,

and have been peopled with living things by such forms only as in some way

or other have been able to reach them across many hundred miles of ocean.

\_The Flora of the Azores.\_--The flowering-plants of the Azores have been

studied by one of our first botanists, Mr. H. C. Watson, who has himself

visited the islands and made extensive collections; and he has given a

complete catalogue of the species in Mr. Godman's volume. As our {257}

object in the present work is to trace the past history of the more

important islands by means of the forms of life that inhabit them, and as

for this purpose plants are sometimes of more value than any class of

animals, it will be well to take advantage of the valuable materials here

available, in order to ascertain how far the evidence derived from the two

organic kingdoms agrees in character; and also to obtain some general

results which may be of service in our discussion of more difficult and

more complex problems.

There are in the Azores 480 known species of flowering-plants and ferns, of

which no less than 440 are found also in Europe, Madeira, or the Canary

Islands; while forty are peculiar to the Azores, but are more or less

closely allied to European species. As botanists are no less prone than

zoologists to invoke former land-connections and continental extensions to

account for the wide dispersal of objects of their study, it will be well

to examine somewhat closely what these facts really imply.

\_The Dispersal of Seeds.\_--The seeds of plants are liable to be dispersed

by a greater variety of agents than any other organisms, while their

tenacity of life, under varying conditions of heat and cold, drought and

moisture, is also exceptionally great. They have also an advantage, in that

the great majority of flowering plants have the sexes united in the same

individual, so that a single seed in a state fit to germinate may easily

stock a whole island. The dispersal of seeds has been studied by Sir Joseph

Hooker, Mr. Darwin, and many other writers, who have made it sufficiently

clear that they are in many cases liable to be carried enormous distances.

An immense number are specially adapted to be carried by the wind, through

the possession of down or hairs, or membranous wings or processes; while

others are so minute, and produced in such profusion, that it is difficult

to place a limit to the distance they might be carried by gales of wind or

hurricanes. Another class of somewhat heavier seeds or dry fruits are

capable of being exposed for a long time to sea-water without injury. Mr.

Darwin made many experiments on this point, and he found that many seeds,

especially of Atriplex, {258} Beta, oats, Capsicum, and the potato, grew

after 100 days' immersion, while a large number survived fifty days. But he

also found that most of them sink after a few days' immersion, and this

would certainly prevent them being floated to very great distances. It is

very possible, however, that dried branches or flower-heads containing

seeds would float longer, while it is quite certain that many tropical

seeds do float for enormous distances, as witness the double cocoa-nuts

which cross the Indian ocean from the Seychelle Islands to the coast of

Sumatra, and the West Indian beans which frequently reach the west coast of

Scotland. There is therefore ample evidence of the possibility of seeds

being conveyed across the sea for great distances by winds and surface

currents.[52]

\_Birds as Seed-carriers.\_--The great variety of fruits that are eaten by

birds afford a means of plant-dispersal in the fact that seeds often pass

through the bodies of birds in a state well-fitted for germination; and

such seeds may occasionally be carried long distances by this means. Of the

twenty-two land-birds found in the Azores, half are, more or less,

fruit-eaters, and these may have been the means of introducing many plants

into the islands.

Birds also frequently have small portions of earth on their feet; and Mr.

Darwin has shown by actual experiment that almost all such earth contains

seeds. Thus in {259} nine grains of earth on the leg of a woodcock a seed

of the toad-rush was found which germinated; while a wounded red-legged

partridge had a ball of earth weighing six and a half ounces adhering to

its leg, and from this earth Mr. Darwin raised no less than eighty-two

separate plants of about five distinct species. Still more remarkable was

the experiment with six and three-quarter ounces of mud from the edge of a

little pond, which, carefully treated under glass, produced 537 distinct

plants! This is equal to a seed for every six grains of mud, and when we

consider how many birds frequent the edges of ponds in search of food, or

come there to drink, it is evident that great numbers of seeds may be

dispersed by this means.

Many seeds have hispid awns, hooks, or prickles which readily attach them

to the feathers of birds, and a great number of aquatic birds nest inland

on the ground; and as these are pre-eminently wanderers, they must often

aid in the dispersal of such plants.[53]

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\_Facilities for Dispersal of Azorean Plants.\_--Now in the course of very

long periods of time the various causes here enumerated would be sufficient

to stock the remotest islands with vegetation, and a considerable part of

the Azorean flora appears well adapted to be so conveyed. Of the 439

flowering-plants in Mr. Watson's list, I find that about forty-five belong

to genera that have either pappus or winged seeds; sixty-five to such as

have very minute seeds; thirty have fleshy fruits such as are greedily

eaten by birds; several have hispid seeds; and eighty-four are glumaceous

plants, which are all probably well-adapted for being carried partly by

winds and partly by currents, as well as by some of the other causes

mentioned. On the other hand we have a very suggestive fact in the absence

from the Azores of most of the trees and shrubs with large and heavy

fruits, however common they may be in Europe. Such are oaks, chestnuts,

hazels, apples, beeches, alders, and firs; while the only trees or large

shrubs are the Portugal laurel, myrtle, laurestinus, elder, \_Laurus

canariensis\_, \_Myrica faya\_, and a doubtfully peculiar juniper--all small

berry-bearers, and therefore likely to have been conveyed by one or other

of the modes suggested above.

There can be little doubt that the truly indigenous flora of the islands is

far more scanty than the number of plants recorded would imply, because a

large but unknown proportion of the species are certainly importations,

voluntary or involuntary, by man. As, however, the general character of the

whole flora is that of the south-western peninsula of Europe, and as most

of the introduced plants have come from the same country, it is almost

impossible now to separate them, and Mr. Watson has not attempted to do so.

The whole flora contains representatives of eighty natural orders and 250

genera: and even if we suppose that one-half the species only are truly

indigenous, {261} there will still remain a wonderfully rich and varied

flora to have been carried, by the various natural means above indicated,

over 900 miles of ocean, more especially as the large proportion of species

identical with those of Europe shows that their introduction has been

comparatively recent, and that it is, probably (as in the case of the

birds) still going on. We may therefore feel sure that we have here by no

means reached the limit of distance to which plants can be conveyed by

natural means across the ocean; and this conclusion will be of great value

to us in investigating other cases where the evidence at our command is

less complete, and the indications of origin more obscure or conflicting.

Of the forty species which are considered to be peculiar to the islands,

all are allied to European plants except six, whose nearest affinities are

in the Canaries or Madeira. Two of the CompositÃ¦ are considered to be

distinct genera, but in this order generic divisions rest on slight

technical distinctions; and the \_Campanula vidalii\_ is very distinct from

any other known species. With these exceptions, most of the peculiar

Azorean species are closely allied to European plants, and are in several

cases little more than varieties of them. While therefore we may believe

that the larger part of the existing flora reached the islands since the

glacial epoch, a portion of it may be more ancient, as there is no doubt

that a majority of the species could withstand some lowering of

temperature; while in such a warm latitude and surrounded with sea, there

would always be many sunny and sheltered spots in which even tender plants

might flourish.

\_Important Deduction from the Peculiarities of the Azorean Fauna and

Flora.\_--There is one conclusion to be drawn from the almost wholly

European character of the Azorean fauna and flora which deserves special

attention, namely, that the peopling of remote islands is not due so much

to ordinary or normal, as to extraordinary and exceptional 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 {262} conveyed

by the regular winds and currents, which are both such as to prevent

European species from reaching the islands. 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 other North Atlantic Islands--Madeira, the Canaries, and the Cape de

Verdes--present analogous phenomena to those of the Azores, but with some

peculiarities dependent on their more southern position, their richer

vegetation, and perhaps their greater antiquity. These have been

sufficiently discussed in my \_Geographical Distribution of Animals\_ (Vol.

I. pp. 208-215); and as we are now dealing with what may be termed typical

examples of oceanic islands, for the purpose of illustrating the laws, and

solving the problems presented by the dispersal of animals, we will pass on

to other cases which have been less fully discussed in that work.

BERMUDA.

The Bermudas are a small group of low islands formed of coral, and blown

coral-sand consolidated into rock. They are situated in 32Â° N. Lat., about

700 miles from North Carolina, and somewhat farther from the Bahama

Islands, and are thus rather more favourably placed for receiving

immigrants from America and its islands than the Azores are with respect to

Europe. There are about 100 islands and islets in all, but their total area

does not exceed fifty square miles. They are surrounded by reefs, some at a

distance of thirty miles from the main group; and the discovery of a layer

of earth with remains of cedar-trees forty-eight feet below the present

high-water mark shows that the islands have once been more extensive and

probably included the whole area now occupied by shoals and reefs.[54]

Immediately beyond these reefs, {263} however, extends a very deep ocean,

while about 450 miles distant in a south-east direction, the deepest part

of the North Atlantic is reached, where soundings of 3,825 and 3,875

fathoms have been obtained. It is clear therefore that these islands are

typically oceanic.

[Illustration: MAP OF BERMUDA AND THE AMERICAN COAST.]

NOTE.--The light tint indicates sea less than 1,000 fathoms deep.

The dark tint ,, ,, more than 1,000 fathoms deep.

The figures show the depth in fathoms.

Soundings were taken by the \_Challenger\_ in four {264} different directions

around Bermuda, and always showed a rapid deepening of the sea to about

2,500 fathoms. This was so remarkable, that in his reports to the

Admiralty, Captain Nares spoke of Bermuda as "a solitary peak rising

abruptly from a base only 120 miles in diameter;" and in another place as

"an isolated peak rising abruptly from a very small base." These

expressions show that Bermuda is looked upon as a typical example of an

"oceanic peak"; and on examining the series of official reports of the

\_Challenger\_ soundings, I can find no similar case, although some coasts,

both of continents and islands, descend more abruptly. In order to show,

therefore, what is the real character of this peak, I have drawn a section

of it on a true scale from the soundings taken in a north and south

direction where the descent is steepest. It will be seen that the slope is

on both sides very easy, being 1 in 16 on the south, and 1 in 19 on the

north. The portion nearest the islands will slope more rapidly, perhaps

reaching in places 1 in 10; but even this is not steeper than many country

roads in hilly countries, while the remainder would be a hardly perceptible

slope. Although generally very low, some parts of these islands rise to 250

feet above the sea-level, consisting of various kinds of limestone rock,

sometimes soft and friable, but often very hard and even crystalline. It

consists of beds which sometimes dip as much as 30Â°, and which also show

great contortions, so that at first sight the islands appear to exhibit on

a small scale the phenomena of a disturbed PalÃ¦ozoic district. It has

however long been known that these rocks are all due to the wind, {265}

which blows up the fine calcareous sand, the product of the disintegration

of coral, shells, serpulÃ¦, and other organisms, forming sand-hills forty

and fifty feet high, which move gradually along, overwhelming the lower

tracts of land behind them. These are consolidated by the percolation of

rain-water, which dissolves some of the lime from the more porous tracts

and deposits it lower down, filling every fissure with stalagmite.

[Illustration: SECTION OF BERMUDA AND ADJACENT SEA BOTTOM.

The figures show the depth in fathoms at fifty-five miles north and

forty-six miles south of the islands respectively.]

\_The Red Clay of Bermuda.\_--Besides the calcareous rocks there is found in

many parts of the islands a layer of red earth or clay, containing about

thirty per cent. of oxide of iron. This very closely resembles, both in

colour and chemical composition, the red clay of the ocean floor, found

widely spread in the Atlantic at depths of from 2,300 to 3,150 fathoms, and

occurring abundantly all round Bermuda. It appears, therefore, at first

sight, as if the ocean bed itself has been here raised to the surface, and

a portion of its covering of red clay preserved; and this is the view

adopted by Mr. Jones in his paper on the "Botany of Bermuda." He says,

after giving the analysis: "This analysis tends to convince us that the

deep chocolate-coloured red clay of the islands found in the lower levels,

and from high-water mark some distance into the sea, originally came from

the ocean floor, and that when by volcanic agency the Bermuda column was

raised from the depths of the sea, its summit, most probably broken in

outline, appeared above the surface covered with this red mud, which in the

course of ages has but slightly changed its composition, and yet possesses

sufficient evidence to prove its identity with that now lying contiguous to

the base of the Bermuda column." But in his \_Guide to Bermuda\_ Mr. Jones

tells us that this same red earth has been found, two feet thick, under

coral rock at a depth of forty-two feet below low-water mark, and that it

"rested on a bed of compact calcareous sandstone." Now it is quite certain

that this "calcareous sandstone" was never formed at the bottom of the deep

ocean 700 miles from land; and the occurrence of the red earth at different

levels upon coralline sand rock is therefore more probably due to some

process of decomposition of the rock itself, {266} or of the minute

organisms which abound in the blown sand.[55]

\_Zoology of Bermuda.\_--As might be expected from their extreme isolation,

these islands possess no indigenous terrestrial mammalia, frogs, or

snakes.[56] There is however one lizard, which Professor Cope considers to

be distinct from any American species, and which he has named \_Plestiodon

(Eumeces) longirostris\_. It is said to be most nearly allied to \_Eumeces

quinquelineatus\_ of the south-eastern States, from which it differs in

having nearly ten more rows of scales, the tail thicker, and the muzzle

longer. In colour it is ashy brown above, greenish blue beneath, with a

white line black-margined on the sides, and it seems to be tolerably

abundant in the islands. This lizard is especially interesting as being the

only vertebrate animal which exhibits any peculiarity.

\_Birds.\_--Notwithstanding its small size, low altitude and {267} remote

position, a great number of birds visit Bermuda annually, some in large

numbers, others only as accidental stragglers. Altogether, over 180 species

have been recorded, rather more than half being wading and swimming birds,

whose presence is not so much to be wondered at as they are great

wanderers; while about eighty-five are land birds, many of which would

hardly be supposed capable of flying so great a distance. Of the 180

species, however, about thirty have only been seen once, and a great many

more are very rare; but about twenty species of land birds are recorded as

tolerably frequent visitors, and nearly half these appear to come every

year.

There are only eleven species which are permanent residents on the

island--eight land, and three water birds, and of these one has been almost

certainly introduced. These resident birds are as follows:--

1. \_Galeoscoptes carolinensis.\_ (The Cat bird.) Migrates along the east

coast of the United States.

2. \_Sialia sialis.\_ (The Blue bird.) Migrates along the east coast.

3. \_Vireo novÃ¦boracensis.\_ (The White-eyed green Tit.) Migrates along

the east coast.

4. \_Passer domesticus.\_ (The English Sparrow.) ? Introduced.

5. \_Corvus americanus.\_ (The American Crow.) Common over all North

America.

6. \_Cardinalis virginianus.\_ (The Cardinal bird.) Migrates from

Carolina southward.

7. \_Chamoepelia passerina.\_ (The ground Dove.) Louisiana, W. Indies,

and Mexico.

8. \_Ortyx virginianus.\_ (The American Quail.) New England to Florida.

9. \_Ardea herodias.\_ (The Great Blue Heron.) All North America.

10. \_Gailinula galeata.\_ (The Florida Gallinule.) Temperate and

tropical North America.

11. \_PhÃ¤eton flavirostris.\_ (The Tropic Bird.)

It will be seen that these are all very common North American birds, and

most of them are constant visitors from the mainland, so that however long

they may have inhabited the islands there has been no chance for them to

have acquired any distinctive characters owing to the want of isolation.

Among the most regular visitants which are not resident, are the common N.

American kingfisher (\_Ceryle alcyon\_), {268} the night-hawk (\_Chordeiles

virginianus\_), the wood wagtail (\_Siurus novÃ¦boracensis\_), the snow-bunting

(\_Plectrophanes nivalis\_), and the wide-ranging rice-bird (\_Dolichonyx

oryzivora\_), all very common and widespread in North America.

\_Comparison of the Bird-faunas of Bermuda and the Azores.\_--The bird-fauna

of Bermuda thus differs from that of the Azores, in the much smaller number

of resident species, and the presence of several regular migrants. This is

due, first, to the small area and little varied surface of these islands,

as well as to their limited flora and small supply of insects not affording

conditions suitable for the residence of many species all the year round;

and, secondly, to the peculiarity of the climate of North America, which

causes a much larger number of its birds to be migratory than in Europe.

The Northern United States and Canada, with a sunny climate, luxuriant

vegetation, and abundant insect-life during the summer, supply food and

shelter to an immense number of insectivorous and frugivorous birds; so

that during the breeding season Canada is actually richer in bird-life than

Florida. But as the severe winter comes on all these are obliged to migrate

southward, some to Carolina, Georgia, and Florida, others as far as the

West Indies, Mexico, or even to Guatemala and South America.

Every spring and autumn, therefore a vast multitude of birds, belonging to

more than a hundred distinct species, migrate northward or southward in

Eastern America. A large proportion of these pass along the Atlantic coast,

and it has been observed that many of them fly some distance out to sea,

passing straight across bays from headland to headland by the shortest

route.

Now as the time of these migrations is the season of storms, especially the

autumnal one, which nearly coincides with the hurricanes of the West Indies

and the northerly gales of the coast of America, the migrating birds are

very liable to be carried out to sea. Sometimes they may, as Mr. Jones

suggests, be carried up by local whirlwinds to a great height, where

meeting with a westerly or north-westerly gale, they are rapidly driven

sea-ward. The great majority no doubt perish, but some reach the Bermudas

{269} and form one of its most striking autumnal features. In October, Mr.

Jones tells us, the sportsman enjoys more shooting than at any other time.

The violent revolving gales, which occur almost weekly, bring numbers of

birds of many species from the American continent, the different members of

the duck tribe forming no inconsiderable portion of the whole; while the

Canada goose, and even the ponderous American swan, have been seen amidst

the migratory host. With these come also such delicate birds as the

American robin (\_Turdus migratorius\_), the yellow-rumped warbler

(\_Dendroeca coronata\_), the pine warbler (\_Dendroeca pinus\_), the wood

wagtail (\_Siurus novÃ¦boracensis\_), the summer red bird (\_Pyranga Ã¦stiva\_),

the snow-bunting (\_Plectrophanes nivalis\_), the red-poll (\_Ãgiothus

linarius\_), the king bird (\_Tyrannus carolinensis\_), and many others. It is

no doubt in consequence of this repeated immigration that none of the

Bermuda birds have acquired any special peculiarity constituting even a

distinct variety; for the few species that are resident and breed in the

islands are continually crossed by individual immigrants of the same

species from the mainland.

Four European birds also have occurred in Bermuda;--the wheatear (\_Saxicola

oenanthe\_), which visits Iceland and Lapland and sometimes the northern

United States; the skylark (\_Alauda arvensis\_), but this was probably an

imported bird or an escape from some ship; the land-rail (\_Crex

pratensis\_), which also wanders to Greenland and the United States; and the

common snipe (\_Scolopax gallinago\_), which occurs not unfrequently in

Greenland but has not yet been noticed in North America. It is however so

like the American snipe (\_S. wilsoni\_), that a straggler might easily be

overlooked.

Two small bats of N. American species also occasionally reach the island,

while two others from the West Indies have more rarely occurred, and these

are the only wild mammalia except rats and mice.

\_Insects of Bermuda.\_--Insects appear to be very scarce; but it is evident

from the lists given by Mr. Jones, and more recently by Professor Heilprin,

that only the more conspicuous species have been yet collected. These {270}

comprise nineteen beetles, eleven bees and wasps, twenty-six butterflies

and moths, nine flies, and the same number of Hemiptera, Orthoptera, and

Neuroptera respectively. All appear to be common North American or West

Indian species; but until some competent entomological collector visits the

islands it is impossible to say whether there are or are not any peculiar

species.[57]

\_Land Mollusca.\_--The land-shells of the Bermudas are somewhat more

interesting, as they appear to be the only group of animals except reptiles

in which there are any peculiar species. The following list was kindly

furnished me by Mr. Thomas Bland of New York, who has made a special study

of the terrestrial molluscs of the West Indian Islands, from which those of

the Bermudas have undoubtedly been derived. The nomenclature has been

corrected in accordance with the list given in Professor Heilprin's work on

the islands. The species which are peculiar to the islands are indicated by

italics.

LIST OF THE LAND-SHELLS OF BERMUDA.

1. Succinea fulgens. (Lea.) Also in Cuba.

2. ,, Bermudensis. (Pfeiffer.) ,, Barbadoes (?)

3. ,, margarita. (Pfr.) ,, Haiti.

4. \_Poecilozonites Bermudensis.\_ (Pfr.) A peculiar form, which, according

to Mr. Binney, "cannot be

placed in any recognised genus."

A larger sub-fossil variety also

occurs, named \_H. Nelsoni\_, by

Mr. Bland, and which appears

sufficiently distinct to be

classed as another species.

5. ,, \_circumfirmatas\_ (Redfield.)

6. ,, \_discrepans.\_ (Pfr.)

7. ,, \_Reinianus.\_ (Pfr.)

8. Patula (Thysanophora) hypolepta (Shuttleworth.)

9. ,, vortex. (Pfr.) Southern Florida and West Indies.

10. Helix microdonta. (Desh.) Bahama Islands, Florida, Texas.

11. ,, appressa. (Say.) Virginia and adjacent states;

perhaps introduced into Bermuda.

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12. ,, pulchella. (MÃ¼ll.) Europe; very close to \_H.

minuta\_ (Say) of the United

States. Introduced into Bermuda

(?)

13. ,, ventricosa. (Drap.) Azores, Canary Islands, and South

Europe.

14. Bulimulus nitidulus. (Pfr.) Cuba, Haiti, &c.

15. Stenogyra octona. (Ch.) West Indies and South America.

16. Stenogyra decollata (Linn.) A South European species.

Introduced.

17. Coecilianella acicula. (MÃ¼ll.) Florida, New Jersey, and Europe.

18. Pupa pellucida. (Pfr.) West Indies, and Yucatan.

19. ,, Barbadensis. (Pfr.) Barbadoes (?)

20. ,, Jamaicensis. (C. B. Ad.) Jamaica.

21. Helicina convexa. (Pfr.) Barbuda.[58]

Mr. Bland indicates only four species as certainly peculiar to Bermuda, and

another sub-fossil species; while one or two of the remainder are indicated

as doubtfully identical with those of other countries. We have thus about

one-fifth of the land-shells peculiar, while almost all the other

productions of the islands are identical with those of the adjacent

continent and islands. This corresponds, however, with what occurs

generally in islands at some distance from continents. In the Azores only

one land-bird is peculiar out of eighteen resident species; the beetles

show about one-eighth of the probably non-introduced species as peculiar;

the plants about one-twentieth; while the land-shells have about half the

species peculiar. This difference is well explained by the much greater

difficulty of transmission over wide seas, in the case of land-shells, than

of any other terrestrial organisms. It thus happens that when a species has

once been conveyed it may remain isolated for unknown ages, and has time to

become modified by local conditions unchecked by the introduction of other

individuals of the original type.

\_Flora of Bermuda.\_--Unfortunately no good account of the plants of these

islands has yet been published. Mr. {272} Jones, in his paper "On the

Vegetation of the Bermudas" gives a list of no less than 480 species of

flowering plants; but this number includes all the culinary plants,

fruit-trees, and garden flowers, as well as all the ornamental trees and

shrubs from various parts of the world which have been introduced, mixed up

with the European and American weeds that have come with agricultural or

garden seeds, and the really indigenous plants, in one undistinguished

series. It appears too, that the late Governor, Major-General Lefroy, "has

sown and distributed throughout the islands packets of seeds from Kew,

representing no less than 600 species, principally of trees and shrubs

suited to sandy coast soils"--so that it will be more than ever difficult

in future years to distinguish the indigenous from the introduced

vegetation.

From the researches of Dr. Rein and Mr. Moseley there appear to be about

250 flowering plants in a wild state, and of these Mr. Moseley thinks less

than half are indigenous. The majority are tropical and West Indian, while

others are common to the Southern States of North America; the former class

having been largely brought by means of the Gulf Stream, the latter by the

agency of birds or by winds. Mr. Jones tells us that the currents bring

numberless objects animate and inanimate from the Carribean Sea, including

the seeds of trees, shrubs, and other plants, which are continually cast

ashore and sometimes vegetate. The soap-berry tree (\_Sapindus saponaria\_)

has been actually observed to originate in this way.

The only \_species\_ of flowering plant peculiar to Bermuda is \_Carex

Bermudiana\_ (Hemsley), which is said to be allied to a species found only

in St. Helena; but there are some local forms of continental species, among

which are \_Sisyrinchium Bermudianum\_ and a variety of \_Rhus toxicodendron\_.

There are, however, two ferns--an Adiantum and a Nephrodium, which are

unknown from any other locality. The juniper, which is so conspicuous a

feature of the islands, is said to be a West Indian species (\_Juniperus

barbadensis\_) found in Jamaica and the Bahamas, not the North American red

{273} cedar; but there seems to be still some doubt about this common

plant.

Mr. Moseley, who visited Bermuda in the \_Challenger\_, has well explained

the probable origin of the vegetation. The large number of West Indian

plants is no doubt due to the Gulf Stream and constant surface drift of

warm water in this direction, while others have been brought by the annual

cyclones which sweep over the intervening ocean. The great number of

American migratory birds, including large flocks of the American golden

plover, with ducks and other aquatic species, no doubt occasionally bring

seeds, either in the mud attached to their feet or in their stomachs.[59]

As these causes are either constantly in action or recur annually, it is

not surprising that almost all the species should be unchanged owing to the

frequent intercrossing of freshly-arrived specimens. If a competent

botanist were thoroughly to explore Bermuda, eliminate the species

introduced by human agency, and investigate the source from whence the

others were derived and the mode by which they had reached so remote an

island, we should obtain important information as to the dispersal of

plants, which might afford us a clue to the solution of many difficult

problems in their geographical distribution.

\_Concluding Remarks.\_--The two groups of islands we have now been

considering furnish us with some most instructive facts as to the power of

many groups of organisms to pass over from 700 to 900 miles of open sea.

There is no doubt whatever that all the indigenous species have thus

reached these islands, and in many cases the process may be seen going on

from year to year. We find that, as regards birds, migratory habits and the

liability to be caught by violent storms are the conditions which determine

the island-population. In both islands the land-birds are almost

exclusively migrants; and in both, the non-migratory groups--wrens, tits,

creepers, and nuthatches--are absent; while the number of annual visitors

is greater in proportion as the migratory habits and prevalence of storms

afford more efficient means for their introduction. {274}

We find also, that these great distances do not prevent the immigration of

some insects of most of the orders, and especially of a considerable number

and variety of beetles; while even land-shells are fairly represented in

both islands, the large proportion of peculiar species clearly indicating

that, as we might expect, individuals of this group of organisms arrive

only at long and irregular intervals.

Plants are represented by a considerable variety of orders and genera, most

of which show some special adaptation for dispersal by wind or water, or

through the medium of birds; and there is no reason to doubt that besides

the species that have actually established themselves, many others must

have reached the islands, but were either not suited to the climate and

other physical conditions, or did not find the insects necessary to their

fertilisation, and were therefore unable to maintain themselves.

If now we consider 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. This

conclusion will be of great importance in those cases where the evidence as

to the exact origin of the fauna and flora of an island is less clear and

satisfactory than in the case of the Azores and Bermuda.

\* \* \* \* \*

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CHAPTER XIII

THE GALAPAGOS ISLANDS

Position and Physical Features--Absence of Indigenous Mammalia and

Amphibia--Reptiles--Birds--Insects and Land-Shells--The Keeling Islands

as Illustrating the Manner in which Oceanic Islands are Peopled--Flora

of the Galapagos--Origin of the Flora of the Galapagos--Concluding

Remarks.

The Galapagos differ in many important respects from the islands we have

examined in our last chapter, and the differences are such as to have

affected the whole character of their animal inhabitants. Like the Azores,

they are volcanic, but they are much more extensive, the islands being both

larger and more numerous; while volcanic action has been so recent that a

large portion of their surface consists of barren lava-fields. They are

considerably less distant from a continent than either the Azores or

Bermuda, being about 600 miles from the west coast of South America and a

little more than 700 from Veragua, with the small Cocos Islands

intervening; and they are situated on the equator instead of being in the

north temperate zone. They stand upon a deeply submerged bank, the 1,000

fathom line encircling all the more important islands at a few miles

distance, whence there appears to be a comparatively steep descent all

round to the average depth of that portion of the Pacific, between 2,000

and 3,000 fathoms. {276}

[Illustration: MAP OF THE GALAPAGOS AND ADJACENT COASTS OF SOUTH AMERICA.]

The light tint shows where the sea is less than 1,000 fathoms deep.

The figures show the depth in fathoms.

The whole group occupies a space of about 300 by 200 miles. It consists of

five large and twelve small islands; the largest (Albemarle Island) being

about eighty miles long and of very irregular shape, while the four next in

importance--Chatham, Indefatigable, James, and Narborough Islands, are each

about twenty-five or thirty miles {277} long, and of a rounded or elongate

form. The whole are entirely volcanic, and in the western islands there are

numerous active volcanoes. Unlike the other groups of islands we have been

considering, these are situated in a comparatively calm sea, where storms

are of rare occurrence and even strong winds almost unknown. They are

traversed by ocean currents which are strong and constant, flowing towards

the north-west from the coast of Peru; {278} and these physical conditions

have had a powerful influence on the animal and vegetable forms by which

the islands are now inhabited. The Galapagos have also, during three

centuries, been frequently visited by Europeans, and were long a favourite

resort of buccaneers and traders, who found an ample supply of food in the

large tortoises which abound there; and to these visits we may perhaps

trace the introduction of some animals whose presence it is otherwise

difficult to account for. The vegetation is generally scanty, but still

amply sufficient for the support of a considerable amount of animal life,

as shown by the cattle, horses, asses, goats, pigs, dogs, and cats, which

now run wild in some of the islands.

[Illustration: MAP OF THE GALAPAGOS.]

The light tint shows a depth of less than 1,000 fathoms.

The figures show the depth in fathoms.

\_Absence of Indigenous Mammalia and Amphibia.\_--As in all other oceanic

islands, we find here no truly indigenous mammalia, for though there is a

mouse of the American genus Hesperomys, which differs somewhat from any

known species, we can hardly consider this to be indigenous; first, because

these creatures have been little studied in South America, and there may

yet be many undescribed species, and in the second place because even had

it been introduced by some European or native vessel, there is ample time

in two or three hundred years for the very different conditions to have

established a marked diversity in the characters of the species. This is

the more probable because there is also a true rat of the Old World genus

Mus, which is said to differ slightly from any known species; and as this

genus is not a native of the American continents we are sure that it must

have been recently introduced into the Galapagos. There can be little doubt

therefore that the islands are completely destitute of truly indigenous

mammalia; and frogs and toads, the only tropical representatives of the

Amphibia, are equally unknown.

\_Reptiles.\_--Reptiles, however, which at first sight appear as unsuited as

mammals to pass over a wide expanse of ocean, abound in the Galapagos,

though the species are not very numerous. They consist of land-tortoises,

lizards and snakes. The tortoises consist of two peculiar species, \_Testudo

microphyes\_, found in most of the islands, and \_T. {279} abingdonii\_

recently discovered on Abingdon Island, as well as one extinct species, \_T.

ephippium\_, found on Indefatigable Island. These are all of very large

size, like the gigantic tortoises of the Mascarene Islands, from which,

however, they differ in structural characters; and Dr. GÃ¼nther believes

that they have been originally derived from the American continent.[60]

Considering the well known tenacity of life of these animals, and the large

number of allied forms which have aquatic or sub-aquatic habits, it is not

a very extravagant supposition that some ancestral form, carried out to sea

by a flood, was once or twice safely drifted as far as the Galapagos, and

thus originated the races which now inhabit them.

The lizards are five in number; a peculiar species of gecko,

\_Phyllodactylus galapagensis\_, and four species of the American family

IguanidÃ¦. Two of these are distinct species of the genus Tropidurus, the

other two being large, and so very distinct as to be classed in peculiar

genera. One of these is aquatic and found in all the islands, swimming in

the sea at some distance from the shore and feeding on seaweed; the other

is terrestrial, and is confined to the four central islands. These last

were originally described as \_Amblyrhynchus cristatus\_ by Mr. Bell, and \_A.

subcristatus\_ by Gray; they were afterwards placed in two other genera

Trachycephalus and Oreocephalus (\_see\_ Brit. Mus. Catalogue of Lizards),

while in a recent paper by Dr. Steindachner, the marine species is again

classed as Amblyrhynchus, while the terrestrial form is placed in another

genus Conolophus, both genera being peculiar to the Galapagos.

How these lizards reached the islands we cannot tell. The fact that they

all belong to American genera or families indicates their derivation from

that continent, while their being all distinct species is a proof that

their arrival took place at a remote epoch, under conditions perhaps

somewhat different from any which now prevail. It is certain that animals

of this order have some means of crossing the sea not possessed by any

other land vertebrates, {280} since they are found in a considerable number

of islands which possess no mammals nor any other land reptiles; but what

those means are has not yet been positively ascertained.

It is unusual for oceanic islands to possess snakes, and it is therefore

somewhat of an anomaly that two species are found in the Galapagos. Both

are closely allied to South American forms, and one is hardly different

from a Chilian snake, so that they indicate a more recent origin than in

the case of the lizards. Snakes it is known can survive a long time at sea,

since a living boa-constrictor once reached the island of St. Vincent from

the coast of South America, a distance of two hundred miles by the shortest

route. Snakes often frequent trees, and might thus be conveyed long

distances if carried out to sea on a tree uprooted by a flood such as often

occurs in tropical climates and especially during earthquakes. To some such

accident we may perhaps attribute the presence of these creatures in the

Galapagos, and that it is a very rare one is indicated by the fact that

only two species have as yet succeeded in obtaining a footing there.

\_Birds.\_--We now come to the birds, whose presence here may not seem so

remarkable, but which yet present features of interest not exceeded by any

other group. About seventy species of birds have now been obtained on these

islands, and of these forty-one are peculiar to them. But all the species

found elsewhere, except one, belong to the aquatic tribes or the waders

which are pre-eminently wanderers, yet even of these eight are peculiar.

The true land-birds are forty-two in number, and all but one are entirely

confined to the Galapagos; while three-fourths of them present such

peculiarities that they are classed in distinct genera. All are allied to

birds inhabiting tropical America, some very closely; while one--the common

American rice-bird which ranges over the whole northern and part of the

southern continents--is the only land-bird identical with those of the

mainland. The following is a list of these land-birds taken from Mr.

Salvin's memoir in the \_Transactions of the Zoological Society\_ for the

year 1876, to which are added nine species collected in 1888 and {281}

described by Mr. Ridgway in the \_Proceedings of the U.S. National Museum\_

(XII. p. 101) and some additional species obtained in 1889.

TURDIDÃ.

1. Nesomimus trifasciatus } This and the two allied species

2. ,, melanotus } are related to a Peruvian bird

3. ,, parvulus } \_Mimus longicaudus\_.

4. ,, macdonaldi (Ridg.)

5. ,, personatus (Ridg.)

MNIOTILTIDÃ.

6. Dendroeca aureola { Closely allied to the wide-ranging

{ \_D. Ã¦stiva\_.

HIRUNDINIDÃ.

7. Progne concolor { Allied to \_P. purpurea\_ of North

{ and South America.

COEREBIDÃ.

8. Certhidea olivacea } A peculiar genus allied to the

9. ,, fusca } Andean genus Conirostrum.

10. ,, cinerascens }

FRINGILLIDÃ.

11. Geospiza magnirostris

12. ,, strenua

13. ,, dubia A distinct genus, but allied to the

14. ,, fortis South American genus Guiraca.

15. ,, nebulosa

16. ,, fuliginosa

17. ,, parvula

18. ,, dentirostris

19. ,, conirostris (Ridg.)

20. ,, media (Ridg.)

21. ,, difficilis (Sharpe)

22. Cactornis scandens

23. ,, assimilis

24. ,, abingdoni

25. ,, pallida A genus allied to the last.

26. ,, brevirostris (Ridg.)

27. ,, hypoleuca (Ridg.) A very peculiar genus allied to

28. Camarhynchus psittaculus Neorhynchus of the west coast

29. ,, crassirostris of Peru.

30. ,, variegatus

31. ,, prosthemelas

32. ,, habeli

33. ,, townsendi (Ridg.)

34. ,, pauper (Ridg.)

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ICTERIDÃ.

35. Dolichonyx oryzivorus Ranges from Canada to Paraguay.

TYRANNIDÃ.

36. Pyrocephalus nanus

37. P. minimus (Ridg.) Allied to \_P. rubincus\_ of Ecuador.

38. Myiarchus magnirostris Allied to West Indian species.

COLUMBIDÃ.

39. Zenaida galapagensis { A peculiar species of a S.

{ American genus.

FALCONIDÃ.

40. Buteo galapagensis A buzzard of peculiar coloration.

STRIGIDÃ.

41. Asio galapagensis } Hardly distinct from the widespread

} \_A. brachyotus.\_

42. Strix punctatissima Allied to \_S. flammea\_ but quite

distinct.

We have here every gradation of difference from perfect identity with the

continental species to genera so distinct that it is difficult to determine

with what forms they are most nearly allied; and it is interesting to note

that this diversity bears a distinct relation to the probabilities of, and

facilities for, migration to the islands. The excessively abundant

rice-bird, which breeds in Canada and swarms over the whole United States,

migrating to the West Indies and South America, visiting the distant

Bermudas almost every year, and extending its range as far as Paraguay, is

the only species of land-bird which remains completely unchanged in the

Galapagos; and we may therefore conclude that some stragglers of the

migrating host reach the islands sufficiently often to keep up the purity

of the breed. Next, we have the almost cosmopolite short-eared owl (\_Asio

brachyotus\_), which ranges from China to Ireland, and from Greenland to the

Straits of Magellan, and of this the Galapagos bird is probably only one of

the numerous varieties. The little wood warbler (\_Dendroeca aureola\_) is

closely allied to a species which {283} ranges over the whole of North

America and as far south as New Grenada. It has also been occasionally met

with in Bermuda, an indication that it has considerable powers of flight

and endurance. The more distinct \_species\_--as the tyrant fly-catchers

(Pyrocephalus and Myiarchus), the ground-dove (Zenaida), and the buzzard

(Buteo), are all allied to non-migratory species peculiar to tropical

America, and of a more restricted range; while the distinct \_genera\_ are

allied to South American groups of thrushes, finches, and sugar-birds which

have usually restricted ranges, and whose habits are such as not to render

them likely to be carried out to sea. The remote ancestral forms of these

birds which, owing to some exceptional causes, reached the Galapagos, have

thus remained uninfluenced by later migrations, and have, in consequence,

been developed into a variety of distinct types adapted to the peculiar

conditions of existence under which they have been placed. Sometimes the

different species thus formed are confined to one or two of the islands

only, as the three species of Certhidea, which are divided between the

islands but do not appear ever to occur together. \_Nesomimus parvulus\_ is

confined to Albemarle Island, and \_N. trifasciatus\_ to Charles Island;

\_Cactornis pallida\_ to Indefatigable Island, \_C. brevirostris\_ to Chatham

Island, and \_C. abingdoni\_ to Abingdon Island.

Now all these phenomena are strictly consistent with the theory of the

peopling of the islands by accidental migrations, if we only allow them to

have existed for a sufficiently long period; and the fact that volcanic

action has ceased on many of the islands, as well as their great extent,

would certainly indicate a considerable antiquity.

The great difference presented by the birds of these islands as compared

with those of the equally remote Azores and Bermudas, is sufficiently

explained by the difference of climatal conditions. At the Galapagos there

are none of those periodic storms, gales, and hurricanes which prevail in

the North Atlantic, and which every year carry some straggling birds of

Europe or North America to the former islands; while, at the same time, the

majority of the tropical American birds are {284} nonmigratory, and thus

afford none of the opportunities presented by the countless hosts of

migrants which pass annually northward and southward along the European,

and especially along the North American coasts. It is strictly in

accordance with these different conditions that we find in one case an

almost perfect identity with, and in the other an almost equally complete

diversity from, the continental species of birds.

\_Insects and Land-shells.\_--The other groups of land-animals add little of

importance to the facts already referred to. The insects are very scanty;

the most plentiful group, the beetles, only furnishing about forty species

belonging to thirty-two genera and nineteen families. The species are

almost all peculiar, as are some of the genera. They are mostly small and

obscure insects, allied either to American or to world-wide groups. The

CarabidÃ¦ and the Heteromera are the most abundant groups, the former

furnishing six and the latter nine species.[61]

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The land-shells are not abundant--about twenty in all, most of them

peculiar species, but not otherwise remarkable. The observation of Captain

Collnet, quoted by Mr. Darwin in his \_Journal\_, 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. Whirlwinds also

have been known to carry quantities of leaves and other vegetable \_dÃ©bris\_

to great heights in the air, and these might be then carried away by strong

upper currents and dropped at great distances, and with them small insects

and mollusca, or their eggs. We must also remember that volcanic islands

are subject to subsidence as well as elevation; and it is quite possible

that during the long period the Galapagos have existed some islands may

have intervened between them and the coast, and have served as

stepping-stones by which the passage to them of various organisms would be

greatly facilitated. Sunken banks, the relics of such islands, are known to

exist in many parts of the ocean, and countless others, no doubt, remain

undiscovered.

\_The Keeling Islands as Illustrating the Manner in which Oceanic Islands

are Peopled.\_--That such causes as have been here adduced are those by

which oceanic islands have been peopled, is further shown by the condition

of equally remote islands which we know are of comparatively recent origin.

Such are the Keeling or Cocos Islands in the Indian Ocean, situated about

the same distance from Sumatra as the Galapagos from South America, but

mere coral reefs, supporting abundance of cocoa-nut palms as their chief

vegetation. These islands were visited by Mr. {286} Darwin, and their

natural history carefully examined. The only mammals are rats, brought by a

wrecked vessel and said by Mr. Waterhouse to be common English rats, "but

smaller and more brightly coloured;" so that we have here an illustration

of how soon a difference of race is established under a constant and

uniform difference of conditions. There are no true land-birds, but there

are snipes and rails, both apparently common Malayan species. Reptiles are

represented by one small lizard, but no account of this is given in the

\_Zoology of the Voyage of the Beagle\_, and we may therefore conclude that

it was an introduced species. Of insects, careful collecting only produced

thirteen species belonging to eight distinct orders. The only beetle was a

small Elater, the Orthoptera were a Gryllus and a Blatta; and there were

two flies, two ants, and two small moths, one a DiopÃ¦a which swarms

everywhere in the eastern tropics in grassy places. All these insects were

no doubt brought either by winds, by floating timber (which reaches the

islands abundantly), or by clinging to the feathers of aquatic or wading

birds; and we only require more time to introduce a greater variety of

species, and a better soil and more varied vegetation, to enable them to

live and multiply, in order to give these islands a fauna and flora equal

to that of the Bermudas. Of wild plants there were only twenty species,

belonging to nineteen genera and to no less than sixteen natural families,

while all were common tropical shore plants.[62] These islands are thus

evidently stocked by waifs and strays brought by the winds and waves; but

their scanty vegetation is mainly due to unfavourable conditions--the

barren coral rock and sand, of which they are wholly composed, together

with exposure to sea-air, being suitable to a very limited number of

species which soon monopolise the surface. With more variety of soil and

aspect a greater variety of plants would establish themselves, and these

would favour the preservation and increase of more insects, birds, and

{287} other animals, as we find to be the case in many small and remote

islands.[63]

\_Flora of the Galapagos.\_--The plants of these islands are so much more

numerous than the known animals, even including the insects, they have been

so carefully studied by eminent botanists, and their relations throw so

much light on the past history of the group, that no apology is needed for

giving a brief outline of the peculiarities and affinities of the flora.

The statements we shall make on this subject will be taken from the Memoir

of Sir Joseph Hooker in the \_LinnÃ¦an Transactions\_ for 1851, founded on Mr.

Darwin's collections, and a later paper by N. J. Andersson in the \_LinnÃ¦a\_

of 1861, embodying more recent discoveries. {288}

The total number of flowering plants known at the latter date was 332, of

which 174 were peculiar to the islands, while 158 were common to other

countries.[64] Of these latter about twenty have been introduced by man,

while the remainder are all natives of some part of America, though about a

third part are species of wide range extending into both hemispheres. Of

those confined to America, forty-two are found in both the northern and

southern continents, twenty-one are confined to South America, while twenty

are found only in North America, the West Indies, or Mexico. This equality

of North American and South American species in the Galapagos is a fact of

great significance in connection with the observation of Sir Joseph Hooker

that the \_peculiar\_ species are allied to the plants of temperate America

or to those of the high Andes, while the non-peculiar species are mostly

such as inhabit the hotter regions of the tropics near the level of the

sea. He also observes that the seeds of this latter class of Galapagos

plants often have special means of transport, or belong to groups whose

seeds are known to stand long voyages and to possess great vitality. Mr.

Bentham also, in his elaborate account of the CompositÃ¦,[65] remarks on the

decided Central American or Mexican affinities of the Galapagos species, so

that we may consider this to be a thoroughly well-established fact.

The most prevalent families of plants in the Galapagos are the CompositÃ¦

(40 sp.), GramineÃ¦ (32 sp.), LeguminosÃ¦ (30 sp.), and EuphorbiaceÃ¦ (29

sp.). Of the CompositÃ¦ most of the species, except such as are common weeds

or shore plants, are peculiar, but there are only two peculiar genera,

allied to Mexican forms and not very distinct; while the genus LipochÃ¦ta,

represented here by a single species, is only found elsewhere in the

Sandwich Islands though it has American affinities.

\_Origin of the Galapagos Flora.\_--These facts are explained by the past

history of the American continent, its {289} separation at various epochs

by arms of the sea uniting the two oceans across what is now Central

America (the last separation being of recent date, as shown by the

considerable number of identical species of fishes on both sides of the

isthmus), and the influence of the glacial epoch in driving the temperate

American flora southward along the mountain plateaus.[66] At the time when

the two oceans were united a portion of the Gulf Stream may have been

diverted into the Pacific, giving rise to a current, some part of which

would almost certainly have reached the Galapagos, and this may have helped

to bring about that singular assemblage of West Indian and Mexican plants

now found there. And as we now believe that the duration of the last

glacial epoch in its successive phases was much longer than the time which

has elapsed since it finally passed away, while throughout the Miocene

epoch the snow-line would often be lowered during periods of high

excentricity, we are enabled to comprehend the nature of the causes which

may have led to the islands being stocked with those north tropical or

mountain types which are so characteristic a feature of that portion of the

Galapagos flora which consists of peculiar species.

On the whole, the flora agrees with the fauna in indicating a moderately

remote origin, great isolation, and changes of conditions affording

facilities for the introduction of organisms from various parts of the

American coast, and even from the West Indian Islands and Gulf of Mexico.

As in the case of the birds, the several islands differ considerably in

their native plants, many species being limited to one or two islands only,

while others extend to several. This is, of course, what might be expected

on any theory of their origin; because, even if the whole of the islands

had once been united and afterwards separated, long continued isolation

would often lead to the differentiation of species, while the varied

conditions to be found upon islands differing in size and altitude as well

as in luxuriance of vegetation, would often lead to the extinction of a

species on one island and its preservation on another. If the several

islands had been equally well {290} explored, it might be interesting to

see whether, as in the case of the Azores, the number of species diminished

in those more remote from the coast; but unfortunately our knowledge of the

productions of the various islands of the group is exceedingly unequal,

and, except in those cases in which representative species inhabit distinct

islands, we have no certainty on the subject. All the more interesting

problems in geographical distribution, however, arise from the relation of

the fauna and flora of the group as a whole to those of the surrounding

continents, and we shall therefore for the most part confine ourselves to

this aspect of the question in our discussion of the phenomena presented by

oceanic or continental islands.

\_Concluding Remarks.\_--The Galapagos offer an instructive contrast with the

Azores, showing how a difference of conditions that might be thought

unimportant may yet produce very striking results in the forms of life.

Although the Galapagos are much nearer a continent than the Azores, the

number of species of plants common to the continent is much less in the

former case than in the latter, and this is still more prominent a

characteristic of the insect and the bird faunas. This difference has been

shown to depend, almost entirely, on the one archipelago being situated in

a stormy, the other in a calm portion of the ocean; and it demonstrates the

preponderating importance of the atmosphere as an agent in the dispersal of

birds, insects, and plants. Yet ocean-currents and surface-drifts are

undoubtedly efficient carriers of plants, and, with plants, of insects and

shells, especially in the tropics; and it is probably to this agency that

we may impute the recent introduction of a number of common Peruvian and

Chilian littoral species, and also of several West Indian types at a more

remote period when the Isthmus of Panama was submerged.

In the case of these islands we see the importance of taking account of

past conditions of sea and land and past changes of climate, in order to

explain the relations of the peculiar or endemic species of their fauna and

flora; and we may even see an indication of the effects of climatal changes

in the northern hemisphere, in the north {291} temperate or alpine

affinities of many of the plants, and even of some of the birds. The

relation between the migratory habits of the birds and the amount of

difference from continental types is strikingly accordant with the fact

that it is almost exclusively migratory birds that annually reach the

Azores and Bermuda; while the corresponding fact that the seeds of those

plants, which are common to the Galapagos and the adjacent continent, have

all--as Sir Joseph Hooker states--some special means of dispersal, is

equally intelligible. The reason why the Galapagos possess four times as

many peculiar species of plants as the Azores is clearly a result of the

less constant introduction of seeds, owing to the absence of storms; the

greater antiquity of the group, allowing more time for specific change; and

the influence of cold epochs and of alterations of sea and land, in

bringing somewhat different sets of plants at different times within the

influence of such modified winds and currents as might convey them to the

islands.

On the whole, then, we have no difficulty in explaining the probable origin

of the flora and fauna of the Galapagos, by means of the illustrative facts

and general principles already adduced.

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CHAPTER XIV

ST. HELENA

Position and Physical Features of St. Helena--Change Effected by

European Occupation--The Insects of St.

Helena--Coleoptera--Peculiarities and Origin of the Coleoptera of St.

Helena--Land-shells of St. Helena--Absence of Fresh-water

Organisms--Native Vegetation of St. Helena--The Relations of the St.

Helena CompositÃ¦--Concluding Remarks on St. Helena.

In order to illustrate as completely as possible the peculiar phenomena of

oceanic islands, we will next examine the organic productions of St. Helena

and of the Sandwich Islands, since these combine in a higher degree than

any other spots upon the globe, extreme isolation from all more extensive

lands, with a tolerably rich fauna and flora whose peculiarities are of

surpassing interest. Both, too, have received considerable attention from

naturalists; and though much still remains to be done in the latter group,

our knowledge is sufficient to enable us to arrive at many interesting

results.

{293} [Illustration: MAP OF THE SOUTH ATLANTIC OCEAN SHOWING THE POSITION

OF ST. HELENA.]

The light tint shows depths of less than 1,000 fathoms.

The figures show depths of the sea in fathoms.

\_Position and Physical Features of St. Helena.\_--This island is situated

nearly in the middle of the South Atlantic Ocean, being more than 1,100

miles from the coast of Africa, and 1,800 from South America. It is about

ten miles long by eight wide, and is wholly volcanic, consisting of ancient

basalts, lavas, and other volcanic products. It is very mountainous and

rugged, bounded for {294} the most part by enormous precipices, and rising

to a height of 2,700 feet above the sea-level. An ancient crater, about

four miles across, is open on the south side, and its northern rim forms

the highest and central ridge of the island. Many other hills and peaks,

however, are more than two thousand feet high, and a considerable portion

of the surface consists of a rugged plateau, having an elevation of about

fifteen hundred to two thousand feet. Everything indicates that St. Helena

is an isolated volcanic mass built up from the depths of the ocean. Mr.

Wollaston remarks: "There are the strongest reasons for believing that the

area of St. Helena was never \_very\_ much larger than it is at present--the

comparatively shallow sea-soundings within about a mile and a half from the

shore revealing an abruptly defined ledge, \_beyond\_ which no bottom is

reached at a depth of 250 fathoms; so that the original basaltic mass,

which was gradually piled up by means of successive eruptions from beneath

the ocean, would appear to have its limit definitely marked out by this

suddenly-terminating submarine cliff--the space between it and the existing

coast-line being reasonably referred to that slow process of disintegration

by which the island has been reduced, through the eroding action of the

elements, to its present dimensions." If we add to this that between the

island and the coast of Africa, in a south-easterly direction, is a

profound oceanic gulf known to reach a depth of 2,860 fathoms, or 17,160

feet, while an equally deep, or perhaps deeper, ocean, extends to the west

and south-west, we shall be satisfied that St. Helena is a true oceanic

island, and that it owes none of its peculiarities to a former union with

any continent or other distant land.

\_Change Effected by European Occupation.\_--When first discovered, in the

year 1501, St. Helena was densely covered with a luxuriant forest

vegetation, the trees overhanging the seaward precipices and covering every

part of the surface with an evergreen mantle. This indigenous vegetation

has been almost wholly destroyed; and although an immense number of foreign

plants have been introduced, and have more or less completely established

themselves, {295} yet the general aspect of the island is now so barren and

forbidding that some persons find it difficult to believe that it was once

all green and fertile. The cause of the change is, however, very easily

explained. The rich soil formed by decomposed volcanic rock and vegetable

deposits could only be retained on the steep slopes so long as it was

protected by the vegetation to which it in great part owed its origin. When

this was destroyed, the heavy tropical rains soon washed away the soil, and

has left a vast expanse of bare rock or sterile clay. This irreparable

destruction was caused in the first place by goats, which were introduced

by the Portuguese in 1513, and increased so rapidly that in 1588, they

existed in thousands. These animals are the greatest of all foes to trees,

because they eat off the young seedlings, and thus prevent the natural

restoration of the forest. They were, however, aided by the reckless waste

of man. The East India Company took possession of the island in 1651, and

about the year 1700 it began to be seen that the forests were fast

diminishing, and required some protection. Two of the native trees, redwood

and ebony, were good for tanning, and to save trouble the bark was

wastefully stripped from the trunks only, the remainder being left to rot;

while in 1709 a large quantity of the rapidly disappearing ebony was used

to burn lime for building fortifications! By the MSS. records quoted in Mr.

Melliss' interesting volume on St. Helena,[67] it is evident that the evil

consequences of allowing the trees to be destroyed were clearly foreseen,

as the following passages show: "We find the place called the Great Wood in

a flourishing condition, full of young trees, where the hoggs (of which

there is a great abundance) do not come to root them up. But the Great Wood

is miserably lessened and destroyed within our memories, and is not near

the circuit and length it was. But we believe it does not contain now less

than fifteen hundred acres of fine woodland and good ground, but no springs

of water but what is salt or brackish, which we take to be the reason that

that part was not inhabited when the people first {296} chose out their

settlements and made plantations; but if wells could be sunk, which the

governor says he will attempt when we have more hands, we should then think

it the most pleasant and healthiest part of the island. But as to

healthiness, we don't think it will hold so if the wood that keeps the land

warm were destroyed, for then the rains, which are violent here, would

carry away the upper soil, and it being a clay marl underneath would

produce but little; as it is, we think in case it were enclosed it might be

greatly improved" ... "When once this wood is gone the island will soon be

ruined" ... "We viewed the wood's end which joins the Honourable Company's

plantation called the Hutts, but the wood is so destroyed that the

beginning of the Great Wood is now a whole mile beyond that place, and all

the soil between being washed away, that distance is now entirely barren."

(MSS. records, 1716.) In 1709 the governor reported to the Court of

Directors of the East India Company that the timber was rapidly

disappearing, and that the goats should be destroyed for the preservation

of the ebony wood, and because the island was suffering from droughts. The

reply was, "The goats are not to be destroyed, being more valuable than

ebony." Thus, through the gross ignorance of those in power, the last

opportunity of preserving the peculiar vegetation of St. Helena, and

preventing the island from becoming the comparatively rocky desert it now

is, was allowed to pass away.[68] Even in a mere {297} pecuniary point of

view the error was a fatal one, for in the next century (in 1810) another

governor reports the total destruction of the great forests by the goats,

and that in consequence the cost of importing fuel for government use was

2,729l. 7s. 8d. for a single year! About this time large numbers of

European, American, Australian, and South African plants were imported, and

many of these ran wild and increased so rapidly as to drive out and

exterminate much of the relics of the native flora; so that now English

broom gorse and brambles, willows and poplars, and some common American,

Cape, and Australian weeds, alone meet the eye of the ordinary visitor.

These, in Sir Joseph Hooker's opinion, render it absolutely impossible to

restore the native flora, which only lingers in a few of the loftiest

ridges and most inaccessible precipices, and is rarely seen except by some

exploring naturalist.

This almost total extirpation of a luxuriant and highly peculiar vegetation

must inevitably have caused the destruction of a considerable portion of

the lower animals which once existed on the island, and it is rather

singular that so much as has actually been discovered should be left to

show us the nature of the aboriginal fauna. Many naturalists have made

small collections during short visits, but we owe our present complete

knowledge of the two most interesting groups of animals, the insects, and

the land-shells, mainly to the late Mr. T. Vernon Wollaston, who, after

having thoroughly explored Madeira and the Canaries, undertook a voyage to

St. Helena for the express purpose of studying its terrestrial fauna, and

resided for six months (1875-76) in a high central position, whence the

loftiest peaks could be explored. The results of his labours are contained

in two volumes,[69] which, like all that he wrote, are models of accuracy

and research, and it is to these volumes that we are indebted for the

interesting and suggestive facts which we here lay before our readers.

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\_Insects--Coleoptera.\_--The total number of species of beetles hitherto

observed at St. Helena is 203, but of these no less than seventy-four are

common and wide-spread insects, which have certainly, in Mr. Wollaston's

opinion, been introduced by human agency. There remain 129 which are

believed to be truly aborigines, and of these all but one are found nowhere

else on the globe. But in addition to this large amount of specific

peculiarity (perhaps unequalled anywhere else in the world) the beetles of

this island are equally remarkable for their generic isolation, and for the

altogether exceptional proportion in which the great divisions of the order

are represented. The species belong to thirty-nine genera, of which no less

than twenty-five are peculiar to the island; and many of these are such

isolated forms that it is impossible to find their allies in any particular

country. Still more remarkable is the fact, that more than two-thirds of

the whole number of indigenous species are Rhyncophora or weevils, while

more than two-fifths (fifty-four species) belong to one family, the

CossonidÃ¦. Now although the Rhyncophora are an immensely numerous group and

always form a large portion of the insect population, they nowhere else

approach such a proportion as this. For example, in Madeira they form

one-sixth of the whole of the indigenous Coleoptera, in the Azores less

than one-tenth, and in Britain one-seventh. Even more interesting is the

fact that the twenty genera to which these insects belong are every one of

them peculiar to the island, and in many cases have no near allies

elsewhere, so that we cannot but look on this group of beetles as forming

the most characteristic portion of the ancient insect fauna. Now, as the

great majority of these are wood borers, and all are closely attached to

vegetation and often to particular species of plants, we might, as Mr.

Wollaston well observes, deduce the former luxuriant vegetation of the

island from the great preponderance of this group, even had we not positive

evidence that it was at no distant epoch densely forest-clad. We will now

proceed briefly to indicate the numbers and peculiarities of each of the

families of beetles which enter into the St. Helena fauna, taking them, not

in {299} systematic order, but according to their importance in the island.

1. RHYNCOPHORA.--This great division includes the weevils and allied

groups, and, as above stated, exceeds in number of species all the other

beetles of the island. Four families are represented; the CossonidÃ¦, with

fifteen peculiar genera comprising fifty-four species, and one minute

insect (\_Stenoscelis hylastoides\_) forming a peculiar genus, but which has

been found also at the Cape of Good Hope. It is therefore impossible to say

of which country it is really a native, or whether it is indigenous to

both, and dates back to the remote period when St. Helena received its

early emigrants. All the CossonidÃ¦ are found in the highest and wildest

parts of the island where the native vegetation still lingers, and many of

them are only found in the decaying stems of tree-ferns, box-wood,

arborescent CompositÃ¦, and other indigenous plants. They are all

pre-eminently peculiar and isolated, having no direct affinity to species

found in any other country. The next family, the TanyrhynchidÃ¦, has one

peculiar genus in St. Helena, with ten species. This genus (Nesiotes) is

remotely allied to European, Australian, and Madeiran insects of the same

family: the habits of the species are similar to those of the CossonidÃ¦.

The TrachyphloeidÃ¦ are represented by a single species belonging to a

peculiar genus not very remote from a European form. The AnthribidÃ¦ again

are highly peculiar. There are twenty-six species belonging to three

genera, all endemic, and so extremely peculiar that they form two new

subfamilies. One of the genera, Acarodes, is said to be allied to a

Madeiran genus.

2. GEODEPHAGA.--These are the terrestrial carnivorous beetles, very

abundant in all parts of the world, especially in the temperate regions of

the northern hemisphere. In St. Helena there are fourteen species belonging

to three genera, one of which is peculiar. This is the \_Haplothorax

burchellii\_, the largest beetle on the island, and now very rare. It

resembles a large black Carabus. There is also a peculiar Calosoma, very

distinct, though resembling in some respects certain African species. The

rest of the {300} Geodephaga, twelve in number, belong to the wide-spread

genus Bembidium, but they are altogether peculiar and isolated, except one,

which is of European type, and alone has wings, all the rest being

wingless.

3. HETEROMERA.--This group is represented by three peculiar genera

containing four species, with two species belonging to European genera.

They belong to the families OpatridÃ¦, MordellidÃ¦, and AnthicidÃ¦.

4. BRACHYELYTRA.--Of this group there are six peculiar species belonging to

four European genera--Homalota, Philonthus, Xantholinus, and Oxytelus.

5. PRIOCERATA.--The families ElateridÃ¦ and AnobiidÃ¦ are each represented by

a peculiar species of a European genus.

6. PHYTOPHAGA.--There are only three species of this tribe, belonging to

the European genus Longitarsus.

7. LAMELLICORNIS.--Here are three species belonging to two genera. One is a

peculiar species of Trox, allied to South African forms; the other two

belong to the peculiar genus Melissius, which Mr. Wollaston considers to be

remotely allied to Australian insects.

8. PSEUDO-TRIMERA.--Here we have the fine lady-bird \_Chilomenus lunata\_,

also found in Africa, but apparently indigenous in St. Helena; and a

peculiar species of Euxestes, a genus only found elsewhere in Madeira.

9. TRICHOPTERYGIDÃ.--These, the minutest of beetles, are represented by one

species of the European and Madeiran genus Ptinella.

10. NECROPHAGA.--One indigenous species of Cryptophaga inhabits St. Helena,

and this is said to be very closely allied to a Cape species.

\_Peculiarities and Origin of the Coleoptera of St. Helena.\_--We see that

the great mass of the indigenous species are not only peculiar to the

island, but so isolated in their characters as to show no close affinity

with any existing insects; while a small number (about one-third of the

whole) have some relations, though often very remote, with species now

inhabiting Europe, Madeira, or South Africa. These facts clearly point to

the very great antiquity of the insect fauna of St. Helena, which has

allowed {301} time for the modification of the originally introduced

species, and their special adaptation to the conditions prevailing in this

remote island. This antiquity is also shown by the remarkable specific

modification of a few types. Thus the whole of the CossonidÃ¦ may be

referred to three types, one species only (\_Hexacoptus ferrugineus\_) being

allied to the European CossonidÃ¦ though forming a distinct genus; a group

of three genera and seven species remotely allied to the \_Stenoscelis

hylastoides\_, which occurs also at the Cape; while a group of twelve genera

with forty-six species have their only (remote) allies in a few insects

widely scattered in South Africa, New Zealand, Europe, and the Atlantic

Islands. In like manner, eleven species of Bembidium form a group by

themselves; and the Heteromera form two groups, one consisting of three

genera and species of OpatridÃ¦ allied to a type found in Madeira, the

other, Anthicodes, altogether peculiar.

Now each of these types may well be descended from a single species which

originally reached the island from some other land; and the great variety

of generic and specific forms into which some of them have diverged is an

indication, and to some extent a measure, of the remoteness of their

origin. The rich insect fauna of Miocene age found in Switzerland consists

mostly of genera which still inhabit Europe, with others which now inhabit

the Cape of Good Hope or the tropics of Africa and South America; and it is

not at all improbable that the origin of the St. Helena fauna dates back to

at least as remote, and not improbably to a still earlier, epoch. But if

so, many difficulties in accounting for its origin will disappear. We know

that at that time many of the animals and plants of the tropics, of North

America, and even of Australia, inhabited Europe; while during the changes

of climate, which, as we have seen, 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 {302} wider areas than they now

inhabit. Neither are we limited to the means of transmission across the

ocean that now exist, because we know that those means have varied greatly.

During such extreme changes of conditions as are implied by glacial periods

and by warm polar climates, great alterations of winds and of

ocean-currents are inevitable, and these are, as we have already proved,

the two great agencies by which the transmission of living things to

oceanic islands has been brought about. At the present time the south-east

trade-winds blow almost constantly at St. Helena, and the ocean-currents

flow in the same direction, so that any transmission of insects by their

means must almost certainly be from South Africa. Now there is undoubtedly

a South African element in the insect-fauna, but there is no less clearly a

European, or at least a north-temperate element, and this is very difficult

to account for by causes now in action. But when we consider that this

northern element is chiefly represented by remote generic affinity, and has

therefore all the signs of great antiquity, we find a possible means of

accounting for it. We have seen that during early Tertiary times an almost

tropical climate extended far into the northern hemisphere, and a temperate

climate to the Arctic regions. But if at this time (as is not improbable)

the Antarctic regions were as much ice-clad as they are now it is certain

that an enormous change must have been produced in the winds. Instead of a

great difference of temperature between each pole and the equator, the

difference would be mainly between one hemisphere and the other, and this

might so disturb the trade winds as to bring St. Helena within the south

temperate region of storms--a position corresponding to that of the Azores

and Madeira in the North Atlantic, and thus subject it to violent gales

from all points of the compass. At this remote epoch the mountains of

equatorial Africa may have been more extensive than they are now, and may

have served as intermediate stations by which some northern insects may

have migrated to the southern hemisphere.

We must remember also that these peculiar forms are said to be northern

only because their nearest allies are {303} now found in the North Atlantic

islands and Southern Europe; but it is not at all improbable that they are

really widespread Miocene types, which have been preserved mainly in

favourable insular stations. They may therefore have originally reached St.

Helena from Southern Africa, or from some of the Atlantic islands, and may

have been conveyed by oceanic currents as well as by winds.[70] This is the

more probable, as a large proportion of the St. Helena beetles live even in

the perfect state within the stems of plants or trunks of trees, while the

eggs and larvÃ¦ of a still larger number are likely to inhabit similar

stations. Drift-wood might therefore be one of the most important agencies

by which these insects reached the island.

Let us now see how far the distribution of other groups support the

conclusions derived from a consideration of the beetles. The Hemiptera have

been studied by Dr. F. Buchanan White, and though far less known than the

beetles, indicate somewhat similar relations. Eight out of twenty-one

genera are peculiar, and the thirteen other genera are for the most part

widely distributed, while one of the peculiar genera is of African type.

The other orders of insects have not been collected or studied with {304}

sufficient care to make it worth while to refer to them in detail; but the

land-shells have been carefully collected and minutely described by Mr.

Wollaston himself, and it is interesting to see how far they agree with the

insects in their peculiarities and affinities.

\_Land-shells of St. Helena.\_--The total number of species is only

twenty-nine, of which seven are common in Europe or the other Atlantic

islands, and are no doubt recent introductions. Two others, though

described as distinct, are so closely allied to European forms, that Mr.

Wollaston thinks they have probably been introduced and have become

slightly modified by new conditions of life; so that there remain exactly

twenty species which may be considered truly indigenous. No less than

thirteen of these, however, appear to be extinct, being now only found on

the surface of the ground or in the surface soil in places where the native

forests have been destroyed and the land not cultivated. These twenty

peculiar species belong to the following genera: Hyalina (3 sp.), Patula (4

sp.), Bulimus (7 sp.), Subulina (3 sp.), Succinea (3 sp.); of which, one

species of Hyalina, three of Patula, all the Bulimi, and two of Subulina

are extinct. The three Hyalinas are allied to European species, but all the

rest appear to be highly peculiar, and to have no near allies with the

species of any other country. Two of the Bulimi (\_B. auris vulpinÃ¦\_ and \_B.

darwinianus\_) are said to somewhat resemble Brazilian, New Zealand, and

Solomon Island forms, while neither Bulimus nor Succinea occur at all in

the Madeira group.

Omitting the species that have probably been introduced by human agency, we

have here indications of a somewhat recent immigration of European types

which may perhaps be referred to the glacial period; and a much more

ancient immigration from unknown lands, which must certainly date back to

Miocene, if not to Eocene, times.

\_Absence of Fresh-water Organisms.\_--A singular phenomenon is the total

absence of indigenous aquatic forms of life in St. Helena. Not a single

water-beetle or fresh-water shell has been discovered; neither do there

seem to be any water-plants in the streams, except the common {305}

water-cress, one or two species of Cyperus, and the Australian \_Isapis

prolifera\_. The same absence of fresh-water shells characterises the

Azores, where, however, there is one indigenous water-beetle. In the

Sandwich Islands also recent observations refer to the absence of

water-beetles, though here there are a few fresh-water shells. It would

appear therefore that the wide distribution of the same generic and

specific forms which so generally characterises fresh-water organisms, and

which has been so well illustrated by Mr. Darwin, has its limits in the

\_very remote\_ oceanic islands, owing to causes of which we are at present

ignorant.

The other classes of animals in St. Helena need occupy us little. There are

no indigenous mammals, reptiles, fresh-water fishes or true land-birds; but

there is one species of wader--a small plover (\_Ãgialitis

sanctÃ¦-helenÃ¦\_)--very closely allied to a species found in South Africa,

but presenting certain differences which entitle it to the rank of a

peculiar species. The plants, however, are of especial interest from a

geographical point of view, and we must devote a few pages to their

consideration as supplementing the scanty materials afforded by the animal

life, thus enabling us better to understand the biological relations and

probable history of the island.

\_Native Vegetation of St. Helena.\_--Plants have certainly more varied and

more effectual means of passing over wide tracts of ocean than any kinds of

animals. Their seeds are often so minute, of such small specific gravity,

or so furnished with downy or winged appendages, as to be carried by the

wind for enormous distances. The bristles or hooked spines of many small

fruits cause them to become easily attached to the feathers of aquatic

birds, and they may thus be conveyed for thousands of miles by these

pre-eminent wanderers; while many seeds are so protected by hard outer

coats and dense inner albumen, that months of exposure to salt water does

not prevent them from germinating, as proved by the West Indian seeds that

reach the Azores or even the west coast of Scotland, and, what is more to

the point, by the fact stated by Mr. Melliss, that large seeds which have

floated from {306} Madagascar or Mauritius round the Cape of Good Hope,

have been thrown on the shores of St. Helena and have then sometimes

germinated!

We have therefore little difficulty in understanding \_how\_ the island was

first stocked with vegetable forms. \_When\_ it was so stocked (generally

speaking), is equally clear. For as the peculiar coleopterous fauna, of

which an important fragment remains, is mainly composed of species which

are specially attached to certain groups of plants, we may be sure that the

plants were there long before the insects could establish themselves.

However ancient then is the insect fauna the flora must be more ancient

still. It must also be remembered that plants, when once established in a

suitable climate and soil, soon take possession of a country and occupy it

almost to the complete exclusion of later immigrants. The fact of so many

European weeds having overrun New Zealand and temperate North America may

seem opposed to this statement, but it really is not so. For in both these

cases the native vegetation has first been artificially removed by man and

the ground cultivated; and there is no reason to believe that any similar

effect would be produced by the scattering of any amount of foreign seed on

ground already completely clothed with an indigenous vegetation. We might

therefore conclude \_Ã  priori\_, that the flora of such an island as St.

Helena would be of an excessively ancient type, preserving for us in a

slightly modified form examples of the vegetation of the globe at the time

when the island first rose above the ocean. Let us see then what botanists

tell us of its character and affinities.

The truly indigenous flowering plants are about fifty in number, besides

twenty-six ferns. Forty of the former and ten of the latter are absolutely

peculiar to the island, and, as Sir Joseph Hooker tells us, "with scarcely

an exception, cannot be regarded as very close specific allies of any other

plants at all. Seventeen of them belong to peculiar genera, and of the

others, all differ so markedly as species from their congeners, that not

one comes under the category of being an insular form of a continental

species." The affinities of this flora are, Sir Joseph Hooker thinks, {307}

mainly African and especially South African, as indicated by the presence

of the genera Phylica, Pelargonium, Mesembryanthemum, Oteospermum, and

Wahlenbergia, which are eminently characteristic of southern extra-tropical

Africa. The sixteen ferns which are not peculiar are common either to

Africa, India, or America, a wide range sufficiently explained by the

dust-like spores of ferns, capable of being carried to unknown distances by

the wind, and the great stability of their generic and specific forms, many

of those found in the Miocene deposits of Switzerland, being hardly

distinguishable from living species. This shows, that identity of \_species\_

of ferns between St. Helena and distant countries does not necessarily

imply a recent origin.

\_The Relation of the St. Helena CompositÃ¦.\_--In an elaborate paper on the

CompositÃ¦,[71] Mr. Bentham gives us some valuable remarks on the affinities

of the seven endemic species belonging to the genera Commidendron,

Melanodendron, Petrobium, and Pisiadia, which forms so important a portion

of the existing flora of St. Helena. He says: "Although nearer to Africa

than to any other continent, those composite denizens which bear evidence

of the greatest antiquity have their affinities for the most part in South

America, while the colonists of a more recent character are South African."

... "Commidendron and Melanodendron are among the woody Asteroid forms

exemplified in the Andine Diplostephium, and in the Australian Olearia.

Petrobium is one of three genera, remains of a group probably of great

antiquity, of which the two others are Podanthus in Chile and Astemma in

the Andes. The Pisiadia is an endemic species of a genus otherwise

Mascarene or of Eastern Africa, presenting a geographical connection

analogous to that of the St. Helena MelhaniÃ¦,[72] with the Mascarene

Trochetia."

Whenever such remote and singular cases of geographical affinity as the

above are pointed out, the first {308} impression is to imagine some mode

by which a communication between the distant countries implicated might be

effected; and this way of viewing the problem is almost universally

adopted, even by naturalists. But if the principles laid down in this work

and in my \_Geographical Distribution of Animals\_ are sound, such a course

is very unphilosophical. For, on the theory of evolution, nothing can be

more certain than that groups now broken up and detached were once

continuous, and that fragmentary groups and isolated forms are but the

relics of once widespread types, which have been preserved in a few

localities where the physical conditions were especially favourable, or

where organic competition was less severe. The true explanation of all such

remote geographical affinities is, that they date back to a time when the

ancestral group of which they are the common descendants had a wider or a

different distribution; and they no more imply any closer connection

between the distant countries the allied forms now inhabit, than does the

existence of living EquidÃ¦ in South Africa and extinct EquidÃ¦ in the

Pliocene deposits of the Pampas, imply a continent bridging the South

Atlantic to allow of their easy communication.

\_Concluding Remarks on St. Helena.\_--The sketch we have now given of the

chief members of the indigenous fauna and flora of St. Helena shows, that

by means of the knowledge we have obtained of past changes in the physical

history of the earth, and of the various modes by which organisms are

conveyed across the ocean, all the more important facts become readily

intelligible. We have here an island of small size and great antiquity,

very distant from every other land, and probably at no time very much less

distant from surrounding continents, which became stocked by chance

immigrants from other countries at some remote epoch, and which has

preserved many of their more or less modified descendants to the present

time. When first visited by civilised man it was in all probability far

more richly stocked with plants and animals, forming a kind of natural

museum or vivarium in which ancient types, perhaps dating back to the

Miocene {309} period, or even earlier, had been saved from the destruction

which has overtaken their allies on the great continents. Unfortunately

many, we do not know how many, of these forms have been exterminated by the

carelessness and improvidence of its civilised but ignorant rulers; and it

is only by the extreme ruggedness and inaccessibility of its peaks and

crater-ridges that the scanty fragments have escaped by which alone we are

able to obtain a glimpse of this interesting chapter in the life-history of

our earth.

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CHAPTER XV

THE SANDWICH ISLANDS

Position and Physical Features--Zoology of the Sandwich

Islands--Birds--Reptiles--Land-shells--Insects--Vegetation of the

Sandwich Islands--Peculiar Features of the Hawaiian Flora--Antiquity of

the Hawaiian Fauna and Flora--Concluding Observations on the Fauna and

Flora of the Sandwich Islands--General Remarks on Oceanic Islands.

The Sandwich Islands are an extensive group of large islands situated in

the centre of the North Pacific, being 2,350 miles from the nearest part of

the American coast--the bay of San Francisco, and about the same distance

from the Marquesas and the Samoa Islands to the south, and the Aleutian

Islands a little west of north. They are, therefore, wonderfully isolated

in mid-ocean, and are only connected with the other Pacific Islands by

widely scattered coral reefs and atolls, the nearest of which, however, are

six or seven hundred miles distant, and are all nearly destitute of animal

or vegetable life. The group consists of seven large inhabited islands

besides four rocky islets; the largest, Hawaii, being seventy miles across

and having an area 3,800 square miles--being somewhat larger than all the

other islands together. A better conception of this large island will be

formed by comparing it with Devonshire, with which it closely agrees both

in size and shape, though its enormous volcanic mountains rise to nearly

14,000 feet high. {311} Three of the smaller islands are each about the

size of Hertfordshire or Bedfordshire, and the whole group stretches from

north-west to south-east for a distance of about 350 miles. Though so

extensive, the entire archipelago is volcanic, and the largest island is

rendered sterile and comparatively uninhabitable by its three active

volcanoes and their widespread deposits of lava.

[Illustration: MAP OF THE SANDWICH ISLANDS.]

The light tint shows where the sea is less than 1,000 fathoms deep.

The figures show the depth in fathoms.

The ocean depths by which these islands are separated from the nearest

continents are enormous. North, east, and south, soundings have been

obtained a little over or under three thousand fathoms, and these profound

deeps extend over a large part of the North Pacific. We may {312} be quite

sure, therefore, that the Sandwich Islands have, during their whole

existence, been as completely severed from the great continents as they are

now; but on the west and south there is a possibility of more extensive

islands having existed, serving as stepping-stones to the island groups of

the Mid-Pacific. This is indicated by a few widely-scattered coral islets,

around which extend {313} considerable areas of less depth, varying from

two hundred to a thousand fathoms, and which \_may\_ therefore indicate the

sites of submerged islands of considerable extent. When we consider that

east of New Zealand and New Caledonia, all the larger and loftier islands

are of volcanic origin, with no trace of any ancient stratified rocks

(except, perhaps, in the Marquesas, where, according to Jules Marcou,

granite and gneiss are said to occur) it seems probable that the

innumerable coral-reefs and atolls, which occur in groups on deeply

submerged banks, mark the sites of bygone volcanic islands, similar to

those which now exist, but which, after becoming extinct, have been lowered

or destroyed by denudation, and finally have altogether disappeared except

where their sites are indicated by the upward-growing coral-reefs. If this

view is correct we should give up all idea of there ever having been a

Pacific continent, but should look upon that vast ocean as having from the

remotest geological epochs been the seat of volcanic forces, which from its

profound depths have gradually built up the islands which now dot its

surface, as well as many others which have sunk beneath its waves. The

number of islands, as well as the total quantity of land-surface, may

sometimes have been greater than it is now, and may thus have facilitated

the transfer of organisms from one group to another, and more rarely even

from the American, Asiatic, or Australian continents. Keeping these various

facts and considerations in view, we may now proceed to examine the fauna

and flora of the Sandwich Islands, and discuss the special phenomena they

present.

[Illustration: MAP OF THE NORTH PACIFIC WITH ITS SUBMERGED BANKS.]

The light tint shows where the sea is less than 1,000 fathoms deep.

The dark tint ,, ,, ,, more than 1,000 fathoms deep.

The figures show the depths in fathoms.

\_Zoology of the Sandwich Islands: Birds.\_--It need hardly be said that

indigenous mammalia are quite unknown in the Sandwich Islands, the most

interesting of the higher animals being the birds, which are tolerably

numerous and highly peculiar. Many aquatic and wading birds which range

over the whole Pacific visit these islands, twenty-five species having been

observed, but even of these six are peculiar--a coot, \_Fulica alai\_; a

moorhen, \_Gallinula galeata\_ var \_sandvichensis\_; a rail with rudimentary

wings, \_Pennula millei\_; a stilt-plover, \_Himantopus knudseni\_; and {314}

two ducks, \_Anas Wyvilliana\_ and \_Bernicla sandvichensis\_. The birds of

prey are also great wanderers. Four have been found in the islands--the

short-eared owl, \_Otus brachyotus\_, which ranges over the greater part of

the globe, but is here said to resemble the variety found in Chile and the

Galapagos; the barn owl, \_Strix flammea\_, of a variety common in the

Pacific; a peculiar sparrow-hawk, \_Accipiter hawaii\_; and \_Buteo

solitarius\_, a buzzard of a peculiar species, and coloured so as to

resemble a hawk of the American subfamily PolyborinÃ¦. It is to be noted

that the genus Buteo abounds in America, but is not found in the Pacific;

and this fact, combined with the remarkable colouration, renders it almost

certain that this peculiar species is of American origin.

The Passeres, or true perching birds, are especially interesting, being all

of peculiar species, and, all but one, belonging to peculiar genera. Their

numbers have been greatly increased since the first edition of this work

appeared, partly by the exertions of American naturalists, and very largely

by the researches of Mr. Scott B. Wilson, who visited the Sandwich Islands

for the purpose of investigating their ornithology, and collected

assiduously in the various islands of the group for a year and a half. This

gentleman is now publishing a finely illustrated work on Hawaiian birds,

and he has kindly furnished me with the following list.

PASSERES OF THE SANDWICH ISLANDS.

MUSCICAPIDÃ (Flycatchers).

1. \_Chasiempis ridgwayi\_ Hawaii.

2. ,, \_sclateri\_ Kauai.

3. ,, \_dolei\_ Kauai.

4. ,, \_gayi\_ Oahu.

5. ,, \_ibidis\_ Oahu.

6. \_PhÃ¦ornis obscura\_ Hawaii.

7. ,, \_myadestina\_ Kauai.

MELIPHAGIDÃ (Honeysuckers).

8. \_Acrulocercus nobilis\_ Hawaii.

9. ,, \_braccalus\_ Kauai.

10. ,, \_apicalis\_ (extinct) Oahu or Maui.

11. \_ChÃ¦toptila angustipluma\_ (extinct) Hawaii.

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DREPANIDIDÃ.

12. \_Drepanis pacifica\_ (extinct) Hawaii.

13. \_Vastiaria coccinea\_ All the Islands.

14. \_Hiniatione vireus\_ Hawaii.

15. ,, \_dolii\_ Maui.

16. ,, \_sanguinea\_ All the Islands.

17. ,, \_montana\_ Lanai.

18. ,, \_chloris\_ Oahu.

19. ,, \_maculata\_ Oahu.

20. ,, \_parva\_ Kauai.

21. ,, \_stejnegeri\_ Kauai.

22. \_Oreomyza bairdi\_ Kauai.

23. \_Hemignathus obscurus\_ Hawaii.

24. ,, \_olivaceus\_ Hawaii.

25. ,, \_lichtensteini\_ Oahu.

26. ,, \_lucidus\_ Oahu.

27. ,, \_stejnegeri\_ Kauai.

28. ,, \_hanapepe\_ Kauai.

29. \_Loxops coccinea\_ Hawaii.

30. ,, \_flammea\_ Molokai.

31. ,, \_aurea\_ Maui.

32. \_Chrysomitridops coeruleorostris\_ Kaui.

33. ,, \_anna\_ (extinct)

FRINGILLIDÃ (Finches).

34. \_Loxioides bailleni\_ Hawaii.

35. \_Psittirostra psittacea\_ All the Islands.

36. \_Chloridops kona\_ Hawaii.

CORVIDÃ (Crows).

37. \_Corvus hawaiiensis\_ Hawaii.

Many of the birds recently described are representative forms found in the

several islands of the group.

Taking the above in the order here given, we have, first, two peculiar

genera of true flycatchers, a family confined to the Old World, but

extending over the Pacific as far as the Marquesas Islands. Next we have

two peculiar genera (with four species) of honeysuckers, a family confined

to the Australian region, and also ranging over all the Pacific Islands to

the Marquesas. We now come to the most important group of birds in the

Sandwich Islands, comprising seven or eight peculiar genera, and twenty-two

species which are believed to form a peculiar family allied to the Oriental

flower-peckers (DiceidÃ¦), and perhaps remotely to the American greenlets

(VireonidÃ¦), or {316} tanagers (TanagridÃ¦). They possess singularly varied

beaks, some having this organ much thickened like those of finches, to

which family some of them have been supposed to belong. In any case they

form a most peculiar group, and cannot be associated with any other known

birds. The last species, and the only one not belonging to a peculiar

genus, is the Hawaiian crow, belonging to the almost universally

distributed genus Corvus.

On the whole, the affinities of these birds are, as might be expected,

chiefly with Australia and the Pacific Islands; but they exhibit in the

buzzard, one of the owls, and perhaps in some of the DrepanididÃ¦, 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. The Galapagos, among the true

oceanic islands, while presenting many peculiarities have only four out of

the ten genera of Passeres peculiar. 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. For further details as to the affinities and

geographical distribution of the genera and species, the reader must

consult Mr. Scott Wilson's work \_The Birds of the Sandwich Islands\_,

already alluded to.

\_Reptiles.\_--The only other vertebrate animals are two lizards. One of

these is a very widespread species, \_Ablepharus poecilopleurus\_, ranging

from the Pacific Islands to West Africa. The other is said to form a

peculiar genus of geckoes, but both its locality and affinities appear to

be somewhat doubtful.

\_Land-shells.\_--The only other group of animals which has been carefully

studied, and which presents features of especial interest, are the

land-shells. These are very numerous, about thirty genera, and between

three and four hundred species having been described; and it is remarkable

that this single group contains as many species of {317} land-shells as all

the other Polynesian Islands from the Pelew Islands and Samoa to the

Marquesas. All the species are peculiar, and about three-fourths of the

whole belong to peculiar genera, fourteen of which constitute the subfamily

AchatinellinÃ¦, entirely confined to this group of islands and constituting

its most distinguishing feature. Thirteen genera (comprising sixty-four

species) are found also in the other Polynesian Islands, but three genera

of AuriculidÃ¦ (Plecotrema, Pedipes, and Blauneria) are not found in the

Pacific, but inhabit--the former genus Australia, China, Bourbon, and Cuba,

the two latter the West Indian Islands. Another remarkable peculiarity of

these islands is the small number of Operculata, which are represented by

only one genus and five species, while the other Pacific Islands have

twenty genera and 115 species, or more than half the number of the

Inoperculata. This difference is so remarkable that it is worth stating in

a comparative form:--

Inoperculata. Operculata. AuriculidÃ¦.

Sandwich Islands 332 5 9

Rest of Pacific Islands 200 115 16

When we remember that in the West Indian Islands the Operculata abound in a

greater proportion than even in the Pacific Islands generally, we are led

to the conclusion that limestone, which is plentiful in both these areas,

is especially favourable to them, while the purely volcanic rocks are

especially unfavourable. The other peculiarities of the Sandwich Islands,

however, such as the enormous preponderance of the strictly endemic

AchatinellinÃ¦, and the presence of genera which occur elsewhere only beyond

the Pacific area in various parts of the great continents, undoubtedly

point to a very remote origin, at a time when the distribution of many of

the groups of mollusca was very different from that which now prevails.

A very interesting feature of the Sandwich group is the extent to which the

species and even the genera are confined to separate islands. Thus the

genera Carelia and Catinella with eight species are peculiar to the island

of Kaui; Bulimella, Apex, Frickella, and Blauneria, to Oahu; Perdicella to

Maui; and Eburnella to Lanai. {318} The Rev. John T. Gulick, who has made a

special study of the AchatinellinÃ¦, informs us that the average range of

the species in this sub-family is five or six miles, while some are

restricted to but one or two square miles, and only very few have the range

of a whole island. Each valley, and often each side of a valley, and

sometimes even every ridge and peak possesses its peculiar species.[73] The

island of Oahu, in which the capital is situated, has furnished about half

the species already known. This is partly due to its being more

forest-clad, but also, no doubt, in part to its being better explored, so

that notwithstanding the exceptional riches of the group, we have no reason

to suppose that there are not many more species to be found in the less

explored islands. Mr. Gulick tells us that the forest region that covers

one of the mountain ranges of Oahu is about forty miles in length, and five

or six miles in width, yet this small territory furnishes about 175 species

of AchatinellidÃ¦, represented by 700 or 800 varieties. The most important

peculiar genus, not belonging to the Achatinella group, is Carelia, with

six species and several named varieties, all peculiar to Kaui, the most

westerly of the large islands. This would seem to show that the small

islets stretching westward, and situated on an extensive bank with less

than a thousand fathoms of water over it, may indicate the position of a

large submerged island whence some portion of the Sandwich Island fauna was

derived.

\_Insects.\_--Owing to the researches of the Rev. T. Blackburn we have now a

fair knowledge of the Coleopterous fauna of these islands. Unfortunately

some of the most productive islands in plants--Kaui and Maui--were very

little explored, but during a residence of six years the equally rich Oahu

was well worked, and the general character of the beetle fauna must

therefore be considered to be pretty accurately determined. Out of 428

species collected, many being obviously recent introductions, no {319} less

than 352 species and 99 of the genera appear to be quite peculiar to the

archipelago. Sixty of these species are CarabidÃ¦, forty-two are

StaphylinidÃ¦, forty are NitidulidÃ¦, twenty are PtinidÃ¦, twenty are CiodidÃ¦,

thirty are AglycyderidÃ¦, forty-five are CurculionidÃ¦, and fourteen are

CerambycidÃ¦, the remainder being distributed among twenty-two other

families. Many important families, such as CicindelidÃ¦, ScaraboeidÃ¦,

BuprestidÃ¦, and the whole of the enormous series of the Phytophaga are

either entirely absent or are only represented by a few introduced species.

In the eight families enumerated above most of the species belong to

peculiar genera which usually contain numerous distinct species; and we may

therefore consider these to represent the descendants of the most ancient

immigrants into the islands.

Two important characteristics of the Coleopterous fauna are, the small size

of the species, and the great scarcity of individuals. Dr. Sharp, who has

described many of them,[74] says they are "mostly small or very minute

insects," and that "there are few--probably it would be correct to say

absolutely none--that would strike an ordinary observer as being

beautiful." Mr. Blackburn says that it was not an uncommon thing for him to

pass a morning on the mountains and to return home with perhaps two or

three specimens, having seen literally nothing else except the few species

that are generally abundant. He states that he "has frequently spent an

hour sweeping flower-covered herbage, or beating branches of trees over an

inverted white umbrella without seeing the sign of a beetle of any kind."

To those who have collected in any tropical or even temperate country on or

near a continent, this poverty of insect life must seem almost incredible;

and it affords us a striking proof of how erroneous are those now almost

obsolete views which imputed the abundance, variety, size, and colour of

insects to the warmth and sunlight and luxuriant vegetation of the tropics.

The facts become quite intelligible, however, if we consider that only

{320} minute insects of certain groups could ever reach the islands by

natural means, and that these, already highly specialised for certain

defined modes of life, could only develop slowly into slightly modified

forms of the original types. Some of the groups, however, are considered by

Dr. Sharp to be very ancient generalised forms, especially the peculiar

family AglycyderidÃ¦, which he looks upon as being "absolutely the most

primitive of all the known forms of Coleoptera, it being a synthetic form

linking the isolated Rhynchophagous series of families with the Clavicorn

series. About thirty species are known in the Hawaiian Islands, and they

exhibit much difference \_inter se\_." A few remarks on each of the more

important of the families will serve to indicate their probable mode and

period of introduction into the islands.

The CarabidÃ¦ consist chiefly of seven peculiar genera of Anchomenini

comprising fifty-one species, and several endemic species of BembidiinÃ¦.

They are highly peculiar and are all of small size, and may have originally

reached the islands in the crevices of the drift wood from N.W. America

which is still thrown on their shores, or, more rarely, by means of a

similar drift from the N.-Western islands of the Pacific.[75] It is

interesting to note that peculiar species of the same groups of CarabidÃ¦

are found in the Azores, Canaries, and St. Helena, indicating that they

possess some special facilities for transmission across wide oceans and for

establishing themselves upon oceanic islands. The StaphylinidÃ¦ present many

peculiar species of known genera. Being still more minute and usually more

ubiquitous than the CarabidÃ¦, there is no difficulty in accounting for

their presence in the islands by the same means of dispersal. The

NitidulidÃ¦, PtinidÃ¦, and CiodidÃ¦ being very small and of varied habits,

either the perfect insects, their eggs or larvÃ¦, may have been introduced

either by water or wind carriage, or through the agency of birds. The

CurculionidÃ¦, being wood bark or nut borers, would have considerable

facilities for transmission by floating timber, fruits, or nuts; and the

eggs or larvÃ¦ of the {321} peculiar CerambycidÃ¦ must have been introduced

by the same means. The absence of so many important and cosmopolitan groups

whose size or constitution render them incapable of being thus transmitted

over the sea, as well as of many which seem equally well adapted as those

which are found in the islands, indicate how rare have been the conditions

for successful immigration; and this is still further emphasized by the

extreme specialisation of the fauna, indicating that there has been no

repeated immigration of the same species which would tend, as in the case

of Bermuda, to preserve the originally introduced forms unchanged by the

effects of repeated intercrossing.

\_Vegetation of the Sandwich Islands.\_--The flora of these islands is in

many respects so peculiar and remarkable, and so well supplements the

information derived from its interesting but scanty fauna, that a brief

account of its more striking features will not be out of place; and we

fortunately have a pretty full knowledge of it, owing to the researches of

the German botanist Dr. W. Hildebrand.[76]

Considering their extreme isolation, their uniform volcanic soil, and the

large proportion of the chief island which consists of barren lava-fields,

the flora of the Sandwich Islands is extremely rich, consisting, so far as

at present known, of 844 species of flowering plants and 155 ferns. This is

considerably richer than the Azores (439 Phanerogams and 39 ferns), which

though less extensive are perhaps better known, or than the Galapagos (332

Phanerogams), which are more strictly comparable, being equally volcanic,

while their somewhat smaller area may perhaps be compensated by their

proximity to the American continent. Even New Zealand with more than twenty

times the area of the Sandwich group, whose soil and climate are much more

varied and whose botany has been thoroughly explored, has not a very much

larger number of flowering plants (935 species), while in ferns it is

barely equal.

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The following list gives the number of indigenous species in each natural

order.

\_Number of Species in each Natural Order in the Hawaiian Flora, excluding

the introduced Plants.\_

DICOTYLEDONS. 48. GentianaceÃ¦ (ErythrÃ¦a) 1

49. LoganiaceÃ¦ 7

1. RanunculaceÃ¦ 2 50. ApocynaceÃ¦ 4

2. MenispermaceÃ¦ 4 51. HydrophyllaceÃ¦ (Nama ...

3. PapaveraceÃ¦ 1 allies Andes) 1

4. CruciferÃ¦ 3 52. OleaceÃ¦ 1

5. CapparidaceÃ¦ 2 53. SolanaceÃ¦ 12

6. ViolaceÃ¦ 8 54. ConvolvulaceÃ¦ 14

7. BixaceÃ¦ 2 55. BoraginaceÃ¦ 3

8. PittosporaceÃ¦ 10 56. ScrophulariaceÃ¦ 2

9. CaryophyllaceÃ¦ 23 57. GesneriaceÃ¦ 24

10. PortulaceÃ¦ 3 58. MyoporaceÃ¦ 1

11. GuttiferÃ¦ 1 59. VerbenaceÃ¦ 1

12. TernstrÃ¦miaceÃ¦ 1 60. LabiatÃ¦ 39

13. MalvaceÃ¦ 14 61. PlantaginaceÃ¦ 2

14. SterculiaceÃ¦ 2 62. NyctaginaceÃ¦ 5

15. TiliaceÃ¦ 1 63. AmarantaceÃ¦ 9

16. GeraniaceÃ¦ 6 64. PhytolaccaceÃ¦ 1

17. ZygophyllaceÃ¦ 1 65. PolygonaceÃ¦ 3

18. OxalidaceÃ¦ 1 66. ChenopodiaceÃ¦ 2

19. RutaceÃ¦ 30 67. LauraceÃ¦ 2

20. IlicineÃ¦ 1 68. ThymelÃ¦aceÃ¦ 7

21. CelastraceÃ¦ 1 69. SantalaceÃ¦ 5

22. RhamnaceÃ¦ 7 70. LoranthaceÃ¦ 1

23. SapindaceÃ¦ 6 71. EuphorbiaceÃ¦ 12

24. AnacardiaceÃ¦ 1 72. UrticaceÃ¦ 15

25. LeguminosÃ¦ 21 73. PiperaceÃ¦ 20

26. RosaceÃ¦ 6

27. SaxifragaceÃ¦ (trees) 2 MONOCOTYLEDONS.

28. DroseraceÃ¦ 1

29. HalorageÃ¦ 1 74. OrchidaceÃ¦ 3

30. MyrtaceÃ¦ 6 75. ScitaminaceÃ¦ 4

31. LythraceÃ¦ 1 76. IridaceÃ¦ 1

32. OnagraceÃ¦ 1 77. TaccaceÃ¦ 1

33. CucurbitaceÃ¦ 8 78. DioscoreaceÃ¦ 2

34. FicoideÃ¦ 1 79. LiliaceÃ¦ 7

35. BegoniaceÃ¦ 1 80. CommelinaceÃ¦ 1

36. UmbelliferÃ¦ 5 81. FlagellariaceÃ¦ 1

37. AraliaceÃ¦ 12 82. JuncaceÃ¦ 1

38. RubiaceÃ¦ 49 83. PalmaceÃ¦ 3

39. CompositÃ¦ 70 84. PandanaceÃ¦ 2

40. LobeliaceÃ¦ 58 85. AraceÃ¦ 2

41. GoodeniaceÃ¦ 8 86. NaiadaceÃ¦ 4

42. VaccinaceÃ¦ 2 87. CyperaceÃ¦ 47

43. EpacridaceÃ¦ 2 88. GraminaceÃ¦ 57

44. SapotaceÃ¦ 3

45. MyrsinaceÃ¦ 5 VASCULAR CRYPTOGAMS.

46. PrimulaceÃ¦ (Lysimachia)

shrubs 6 Ferns 136

47. PlumbaginaceÃ¦ 1 LycopodiaceÃ¦ 17

RhizocarpeÃ¦ 2

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\_Peculiar Features of the Flora.\_--This rich insular flora is wonderfully

peculiar, for if we deduct 115 species, which are believed to have been

introduced by man, there remain 705 species of flowering plants of which

574, or more than four-fifths, are quite peculiar to the islands. There are

no less than 38 peculiar genera out of a total of 265 and these 38 genera

comprise 254 species, so that the most isolated forms are those which most

abound and thus give a special character to the flora. Besides these

peculiar types, several genera of wide range are here represented by highly

peculiar species. Such are the Hawaiian species of Lobelia which are woody

shrubs either creeping or six feet high, while a species of one of the

peculiar genera of LobeliaceÃ¦ is a tree reaching a height of forty feet.

Shrubby geraniums grow twelve or fifteen feet high, and some vacciniums

grow as epiphytes on the trunks of trees. Violets and plantains also form

tall shrubby plants, and there are many strange arborescent compositÃ¦, as

in other oceanic islands.

The affinities of the flora generally are very wide. Although there are

many Polynesian groups, yet Australian, New Zealand, and American forms are

equally represented. Dr. Pickering notes the total absence of a large

number of families found in Southern Polynesia, such as DilleniceÃ¦a,

AnonaceÃ¦, OlacaceÃ¦, AurantiaceÃ¦, GuttiferÃ¦, MalpighiaceÃ¦, MeliaceÃ¦,

CombretaceÃ¦, RhizophoraceÃ¦, MelastomaceÃ¦, PassifloraceÃ¦, CunoniaceÃ¦,

JasminaceÃ¦, AcanthaceÃ¦, MyristicaceÃ¦, and CasuaraceÃ¦, as well as the genera

Clerodendron, Ficus, and epidendric orchids. Australian affinities are

shown by the genera Exocarpus, Cyathodes, Melicope, Pittosporum, and by a

phyllodinous Acacia. New Zealand is represented by Ascarina, Coprosma,

AcÃ¦na, and several CyperaceÃ¦; while America is represented by the genera

Nama, Gunnera, Phyllostegia, Sisyrinchium, and by a red-flowered Rubus and

a yellow-flowered Sanicula allied to Oregon species.

There is no true alpine flora on the higher summits, but several of the

temperate forms extend to a great elevation. Thus Mr. Pickering records

Vaccinium, Ranunculus, Silene, Gnaphalium and Geranium, as occurring above

ten {324} thousand feet elevation; while Viola, Drosera, AcÃ¦na, Lobelia,

Edwardsia, DodonÃ¦a, Lycopodium, and many CompositÃ¦, range above six

thousand feet. Vaccinium and Silene are very interesting, as they are

almost peculiar to the North Temperate zone; while many plants allied to

Antarctic species are found in the bogs of the high plateaux.

The proportionate abundance of the different families in this interesting

flora is as follows:--

1. CompositÃ¦ 70 species, 12. UrticaceÃ¦ 15 species,

2. LobeliaceÃ¦ 58 ,, 13. MalvaceÃ¦ 14 ,,

3. GraminaceÃ¦ 57 ,, 14. ConvolvulaceÃ¦ 14 ,,

4. RubiaceÃ¦ 49 ,, 15. AraliaceÃ¦ 12 ,,

5. CyperaceÃ¦ 47 ,, 16. SolanaceÃ¦ 12 ,,

6. LabiatÃ¦ 39 ,, 17. EuphorbiaceÃ¦ 12 ,,

7. RutaceÃ¦ 30 ,, 18. PittosporaceÃ¦ 10 ,,

8. GesneriaceÃ¦ 24 ,, 19. AmarantaceÃ¦ 9 ,,

9. CaryophyllaceÃ¦ 23 ,, 20. ViolaceÃ¦ 8 ,,

10. LeguminosÃ¦ 21 ,, 21. GoodeniaceÃ¦ 8 ,,

11. PiperaceÃ¦ 20 ,,

Nine other orders, GeraniaceÃ¦, RhamnaceÃ¦, RosaceÃ¦, MyrtaceÃ¦, PrimulaceÃ¦,

LoganiaceÃ¦, LiliaceÃ¦, ThymelaceÃ¦, and CucurbitaceÃ¦, have six or seven

species each; and among the more important orders which have less than five

species each are RanunculaceÃ¦, CruciferÃ¦, VaccinacÃ¦, ApocynaceÃ¦,

BoraginaceÃ¦, ScrophulariaceÃ¦, PolygonaceÃ¦, OrchidaceÃ¦, and JuncaceÃ¦. The

most remarkable feature here is the great abundance of LobeliaceÃ¦, a

character of the flora which is probably unique; while the superiority of

LabiatÃ¦ to LeguminosÃ¦ and the scarcity of RosaceÃ¦ and OrchidaceÃ¦ are also

very unusual. Composites, as in most temperate floras, stand at the head of

the list, and it will be interesting to note the affinities which they

indicate. Omitting eleven species which are cosmopolitan, and have no doubt

entered with civilised man, there remain nineteen genera and seventy

species of CompositÃ¦ in the islands. Sixty-one of the species are peculiar,

as are eight of the genera; while the genus LipochÃ¦ta with eleven species

is only known elsewhere in the Galapagos, where a single species occurs. We

may therefore consider that nine out of the nineteen genera of Hawaiian

{325} CompositÃ¦ are really confined to the Archipelago. The relations of

the peculiar genera and species are indicated in the following table.[77]

\_Affinities of Hawaiian Composites.\_

No. of

Peculiar Genera. Species. External Affinities of the Genus.

Remya 2 Very peculiar. Allied to the North American

genus Grindelia.

Tetramolobium 7 South Temperate America and Australia.

LipochÃ¦ta 11 Allied to American genera.

CampylothÃ¦ca 12 With Tropical American species of Bidens and

Coreopsis.

Argyroxiphium 2 With the Mexican MadieÃ¦.

Wilkesia 2 Same affinities.

Dubantia 6 With the Mexican Raillardella.

Raillardia 12 Same affinities.

Hesperomannia 2 Allied to Stifftia and Wunderlichia of Brazil.

Peculiar Species.

Lagenophora 1 Australia, New Zealand, Antarctic America,

Fiji Islands.

Senecio 2 Universally distributed.

Artemisia 2 North Temperate Regions.

The great preponderance of American relations in the CompositÃ¦, as above

indicated, is very interesting and suggestive, since the CompositÃ¦ of

Tahiti and the other Pacific Islands are allied to Malaysian types. It is

here that we meet with some of the most isolated and remarkable forms,

implying great antiquity; and when we consider the enormous extent and

world-wide distribution of this order (comprising about ten thousand

species), its distinctness from all others, the great specialisation of its

flowers to attract insects, and of its seeds for dispersal by wind and

other means, we can hardly doubt that its origin dates back to a very

remote epoch. We may therefore look upon the CompositÃ¦ as representing the

most ancient portion of the existing flora of the Sandwich Islands,

carrying us back to 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 {326} 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, as shown on our map. 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 Ocean.

It is in the smaller and most woody islands in the westerly portion of the

group, especially in Kauai and Oahu, that the greatest number and variety

of plants are found and the largest proportion of peculiar species and

genera. These are believed to form the oldest portion of the group, the

volcanic activity having ceased and allowed a luxuriant vegetation more

completely to cover the islands, while in the larger and much newer islands

of Hawaii and Maui the surface is more barren and the vegetation

comparatively monotonous. Thus while twelve of the arborescent LobeliaceÃ¦

have been found on Hawaii no less than seventeen occur on the much smaller

Oahu, which has even a genus of these plants confined to it.

It is interesting to note that while the non-peculiar genera of flowering

plants have little more than two species to a genus, the endemic genera

average six and three-quarter species to a genus. These may be considered

to represent the earliest immigrants which became firmly established in the

comparatively unoccupied islands, and have gradually become modified into

such complete harmony with their new conditions that they have developed

into many diverging forms adapting them to different \_habitats\_. The

following is a list of the peculiar genera with the number of species in

each. {327}

\_Peculiar Hawaiian Genera of Flowering Plants.\_

Genus. No. of Species. Natural Order.

1. Isodendrion 3 ViolaceÃ¦.

2. Schiedea (seeds rugose or muricate) 17 CaryophyllaceÃ¦.

3. Alsinidendron 1 ,,

4. Pelea 20 RutaceÃ¦.

5. Platydesma 4 ,,

6. Mahoe 1 SapindaceÃ¦.

7. Broussaisia 2 SaxifragaceÃ¦.

8. Hildebrandia 1 BegoniaceÃ¦.

9. Cheirodendron (fleshy fruit) 2 AraliaceÃ¦.

10. Pterotropia (succulent) 3 ,,

11. Triplasandra (drupe) 4 ,,

12. Kadua (small, flat, winged seeds) 16 RubiaceÃ¦.

13. Gouldia (berry) 5 ,,

14. Bobea (drupe) 5 ,,

15. Straussia (drupe) 5 ,,

16. Remya 2 CompositÃ¦.

17. Tetramolobium 7 ,,

18. LipochÃ¦ta 11 ,,

19. Campylotheca 12 ,,

20. Argyroxiphium 2 ,,

21. Wilkesia 2 ,,

22. Dubautia 6 ,,

23. Raillardia 12 ,,

24. Hesperomannia 2 ,,

25. Brighamia 1 LobeliaceÃ¦.

26. Clermontia (berry) 11 ,,

27. Rollandia 6 ,,

28. Delissea 7 ,,

29. Cyanea 28 ,,

30. Labordea 9 LoganiaceÃ¦.

31. Nothocestrum 4 SolanaceÃ¦.

32. Haplostachys (nucules dry) 3 LabiatÃ¦.

33. Phyllostegia (nucules fleshy) 16 ,,

34. Stenogyne (nucules fleshy) 16 ,,

35. Nototrichium 3 AmarantaceÃ¦.

36. Charpentiera 2 ,,

37. Touchardia 1 UrticaceÃ¦.

38. Neraudia 2 ,,

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Total 254 species.

The great preponderance of the two orders CompositÃ¦ and LobeliaceÃ¦ are what

first strike us in this list. In the former case the facilities for

wind-dispersal afforded by the structure of so many of the seeds render it

comparatively easy to account for their having reached the islands at an

early period. The Lobelias, judging from Hildebrand's descriptions, may

have been transported in several {328} different ways. Most of the endemic

genera are berry-bearers and thus offer the means of dispersal by

fruit-eating birds. The endemic species of the genus Lobelia have sometimes

very minute seeds, which might be carried long distances by wind, while

other species, especially Lobelia gaudichaudii, have a "hard, almost woody

capsule which opens late," apparently well adapted for floating long

distances. Afterwards "the calycine covering withers away, leaving a

fenestrate woody network" enclosing the capsule, and the seeds themselves

are "compressed, reniform, or orbicular, and margined," and thus of a form

well adapted to be carried to great heights and distances by gales or

hurricanes.

In the other orders which present several endemic genera indications of the

mode of transit to the islands are afforded us. The AraliaceÃ¦ are said to

have fleshy fruits or drupes more or less succulent. The RubiaceÃ¦ have

usually berries or drupes, while one genus, Kadua, has "small, flat, winged

seeds." The two largest genera of the LabiatÃ¦ are said to have "fleshy

nucules," which would no doubt be swallowed by birds.[78]

\_Antiquity of the Hawaiian Fauna and Flora.\_--The great antiquity implied

by the peculiarities of the fauna and flora, no less than by the

geographical conditions and surroundings, of this group, will enable us to

account for another peculiarity of its flora--the absence of so many

families found in other Pacific Islands. For the earliest immigrants would

soon occupy much of the surface, and become specially modified in

accordance with the conditions of the locality, and these would serve as a

barrier against the intrusion of many forms which at a later {329} period

spread over Polynesia. The extreme remoteness of the islands, and the

probability that they have always been more isolated than those of the

Central Pacific, would also necessarily result in an imperfect and

fragmentary representation of the flora of surrounding lands.

\_Concluding Observations on the Fauna and Flora of the Sandwich

Islands.\_--The indications thus afforded by a study of the flora seem to

accord well with what we know of the fauna of the islands. Plants having so

much greater facilities for dispersal than animals, and also having greater

specific longevity and greater powers of endurance under adverse

conditions, exhibit in a considerable degree the influence of the primitive

state of the islands and their surroundings; while members of the animal

world, passing across the sea with greater difficulty and subject to

extermination by a variety of adverse conditions, retain much more of the

impress of a recent state of things, with perhaps here and there an

indication of that ancient approach to America so clearly shown in the

CompositÃ¦ and some other portions of the flora.

GENERAL REMARKS ON OCEANIC ISLANDS.

We have now reviewed the main features presented by the assemblages of

organic forms which characterise the more important and best known of the

Oceanic Islands. They all agree in the total absence of indigenous mammalia

and amphibia, while their reptiles, when they possess any, do not exhibit

indications of extreme isolation and antiquity. Their birds and insects

present just that amount of specialisation and diversity from continental

forms which may be well explained by the known means of dispersal acting

through long periods; their land shells indicate greater isolation, owing

to their admittedly less effective means of conveyance across the ocean;

while their plants show most clearly the effects of those changes of

conditions which we have reason to believe have occurred during the

Tertiary epoch, and preserve to us in highly specialised and archaic forms

some record of the primeval immigration by which the islands were

originally {330} clothed with vegetation. But in every case the series of

forms of life in these islands is scanty and imperfect as compared with far

less favourable continental areas, and no one of them presents such an

assemblage of animals or plants as we always find in an island which we

know has once formed part of a continent.

It is still more important to note that none of these oceanic archipelagoes

present us with a single type which we may suppose to have been preserved

from Mesozoic times; and this fact, taken in connection with the volcanic

or coralline origin of all of them, powerfully enforces the conclusion at

which we have arrived in the earlier portion of this volume, that during

the whole period of geologic time as indicated by the fossiliferous rocks,

our continents and oceans have, speaking broadly, been permanent features

of our earth's surface. For had it been otherwise--had sea and land changed

place repeatedly as was once supposed--had our deepest oceans been the seat

of great continents while the site of our present continents was occupied

by an oceanic abyss--is it possible to imagine that no fragments of such

continents would remain in the present oceans, bringing down to us some of

their ancient forms of life preserved with but little change? The

correlative facts, that the islands of our great oceans are all volcanic

(or coralline built probably upon degraded volcanic islands or extinct

submarine volcanoes), and that their productions are all more or less

clearly related to the existing inhabitants of the nearest continents, are

hardly consistent with any other theory than the permanence of our oceanic

and continental areas.

We may here refer to the one apparent exception, which, however, lends

additional force to the argument. New Zealand is sometimes classed as an

oceanic island, but it is not so really; and we shall discuss its

peculiarities and probable origin further on.

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CHAPTER XVI

CONTINENTAL ISLANDS OF RECENT ORIGIN: GREAT BRITAIN

Characteristic Features of Recent Continental Islands--Recent Physical

Changes of the British Isles--Proofs of Former Elevation--Submerged

Forests--Buried River Channels--Time of Last Union with the

Continent--Why Britain is poor in Species--Peculiar British

Birds--Freshwater Fishes--Cause of Great Speciality in Fishes--Peculiar

British Insects--Lepidoptera Confined to the British

Isles--Peculiarities of the Isle of Man--Lepidoptera--Coleoptera

confined to the British Isles--Trichoptera Peculiar to the British

Isles--Land and Freshwater Shells--Peculiarities of the British

Flora--Peculiarities of the Irish Flora--Peculiar British Mosses and

HepaticÃ¦--Concluding Remarks on the Peculiarities of the British Fauna

and Flora.

We now proceed to examine those islands which are the very reverse of the

"oceanic" class, being fragments of continents or of larger islands from

which they have been separated, by subsidence of the intervening land at a

period which, geologically, must be considered recent. Such islands are

always still connected with their parent land by a shallow sea, usually

indeed not exceeding a hundred fathoms deep; they always possess mammalia

and reptiles either wholly or in large proportion identical with those of

the mainland; while their entire flora and fauna is characterised either by

the total absence or comparative scarcity of those endemic or peculiar

species and genera which are so striking a feature of almost all oceanic

islands. Such islands will, of course, differ from each {332} other in

size, in antiquity, and in the richness of their respective faunas, as well

as in their distance from the parent land and the facilities for

intercommunication with it; and these diversities of conditions will

manifest themselves in the greater or less amount of speciality of their

animal productions.

This speciality, when it exists, may have been brought about in two ways. A

species or even a genus may on a continent have had a very limited area of

distribution, and this area may be wholly or almost wholly contained in the

separated portion or island, to which it will henceforth be peculiar. Even

when the area occupied by a species is pretty equally divided at the time

of separation between the island and the continent, it may happen that it

will become extinct on the latter, while it may survive on the former,

because the limited number of individuals after division may be unable to

maintain themselves against the severer competition or more contrasted

climate of the continent, while they may flourish, under the more

favourable insular conditions. On the other hand, when a species continues

to exist in both areas, it may on the island be subjected to some

modifications by the altered conditions, and may thus come to present

characters which differentiate it from its continental allies and

constitute it a new species. We shall in the course of our survey meet with

cases illustrative of both these processes.

The best examples of recent continental islands are Great Britain and

Ireland, Japan, Formosa, and the larger Malay Islands, especially Borneo,

Java, and Celebes; and as each of these presents special features of

interest, we will give a short outline of their zoology and past history in

relation to that of the continents from which they have recently been

separated, commencing with our own islands, to which the present chapter

will be devoted.

\_Recent Physical Changes in the British Isles.\_--Great Britain is perhaps

the most typical example of a large and recent continental island now to be

found upon the globe. It is joined to the Continent by a shallow bank which

extends from Denmark to the Bay of Biscay, the 100 fathom line from these

extreme points receding from the {333} coasts so as to include the whole of

the British Isles and about fifty miles beyond them to the westward. (\_See\_

Map.)

[Illustration: MAP SHOWING THE SHALLOW BANK CONNECTING THE BRITISH ISLES

WITH THE CONTINENT.]

The light tint indicates a depth of less than 100 fathoms.

The figures show the depth in fathoms.

The narrow channel between Norway and Denmark is 2,580 feet deep.

Beyond this line the sea deepens rapidly to the 500 and 1,000 fathom lines,

the distance between 100 and 1,000 {334} fathoms being from twenty to fifty

miles, except where there is a great outward curve to include the Porcupine

Bank 170 miles west of Galway, and to the north-west of Caithness where a

narrow ridge less than 500 fathoms below the surface joins the extensive

bank under 300 fathoms, on which are situated the Faroe Islands and

Iceland, and which stretches across to Greenland. In the North Channel

between Ireland and Scotland, and in the Minch between the outer Hebrides

and Skye, are a series of hollows in the sea-bottom from 100 to 150 fathoms

deep. These correspond exactly to the points between the opposing highlands

where the greatest accumulations of ice would necessarily occur during the

glacial epoch, and they may well be termed submarine lakes, of exactly the

same nature as those which occur in similar positions on land.

\_Proofs of Former Elevation--Submerged Forests.\_--What renders Britain

particularly instructive as an example of a recent continental island is

the amount of direct evidence that exists, of several distinct kinds,

showing that the land has been sufficiently elevated (or the sea depressed)

to unite it with the Continent,--and this at a very recent period. The

first class of evidence is the existence, all round our coasts, of the

remains of submarine forests often extending far below the present

low-water mark. Such are the submerged forests near Torquay in Devonshire,

and near Falmouth in Cornwall, both containing stumps of trees in their

natural position rooted in the soil, with deposits of peat, branches, and

nuts, and often with remains of insects and other land animals. These occur

in very different conditions and situations, and some have been explained

by changes in the height of the tide, or by pebble banks shutting out the

tidal waters from estuaries; but there are numerous examples to which such

hypotheses cannot apply, and which can only be explained by an actual

subsidence of the land (or rise of the sea-level) since the trees grew.

We cannot give a better idea of these forests than by quoting the following

account by Mr. Pengelly of a visit to one which had been exposed by a

violent storm on the coast of Devonshire, at Blackpool near Dartmouth:--

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"We were so fortunate as to reach the beach at spring-tide low-water, and

to find, admirably exposed, by far the finest example of a submerged forest

which I have ever seen. It occupied a rectangular area, extending from the

small river or stream at the western end of the inlet, about one furlong

eastward; and from the low-water line thirty yards up the strand. The lower

or seaward portion of the forest area, occupying about two-thirds of its

entire breadth, consisted of a brownish drab-coloured clay, which was

crowded with vegetable \_dÃ©bris\_, such as small twigs, leaves, and nuts.

There were also numerous prostrate trunks and branches of trees, lying

partly imbedded in the clay, without anything like a prevalent direction.

The trunks varied from six inches to upwards of two feet in diameter. Much

of the wood was found to have a reddish or bright pink hue, when fresh

surfaces were exposed. Some of it, as well as many of the twigs, had almost

become a sort of ligneous pulp, while other examples were firm, and gave a

sharp crackling sound on being broken. Several large stumps projected above

the clay in a vertical direction, and sent roots and rootlets into the soil

in all directions and to considerable distances. It was obvious that the

movement by which the submergence was effected had been so uniform as not

to destroy the approximate horizontality of the old forest ground. One fine

example was noted of a large prostrate trunk having its roots still

attached, some of them sticking up above the clay, while others were buried

in it. Hazelnuts were extremely abundant--some entire, others broken, and

some obviously gnawed.... It has been stated that the forest area reached

the spring-tide low-water line; hence as the greatest tidal range on this

coast amounts to eighteen feet, we are warranted in inferring that the

subsidence amounted to eighteen feet as a minimum, even if we suppose that

some of the trees grew in a soil the surface of which was not above the

level of high water. There is satisfactory evidence that in Torbay it was

not less than forty feet, and that in Falmouth Harbour it amounted to at

least sixty-seven feet."[79]

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On the coast of the Bristol Channel similar deposits occur, as well as

along much of the coast of Wales and in Holyhead Harbour. It is believed by

geologists that the whole Bristol Channel was, at a comparatively recent

period, an extensive plain, through which flowed the River Severn; for in

addition to the evidence of submerged forests there are on the coast of

Glamorganshire numerous caves and fissures in the face of high sea cliffs,

in one of which no less than a thousand antlers of the reindeer were found,

the remains of animals which had been devoured there by bears and hyÃ¦nas;

facts which can only be explained by the existence of some extent of dry

land stretching seaward from the present cliffs, but since submerged and

washed away. This plain may have continued down to very recent times, since

the whole of the Bristol Channel to beyond Lundy Island is under

twenty-five fathoms deep. In the east of England we have a similar

forest-bed at Cromer in Norfolk; and in the north of Holland an old land

surface has been found fifty-six feet below high-water mark.

\_Buried River Channels.\_--Still more remarkable are the buried river

channels which have been traced on many parts of our coasts. In order to

facilitate the study of the glacial deposits of Scotland, Dr. James Croll

obtained the details of about 250 bores put down in all parts of the mining

districts of Scotland for the purpose of discovering minerals.[80] These

revealed the interesting fact that there are ancient valleys and river

channels at depths of from 100 to 260 feet below the present sea-level.

These old rivers sometimes run in quite different directions from the

present lines of drainage, connecting what are now distinct valleys; and

they are so completely filled up and hidden by boulder clay, drift, and

sands, that there is no indication of their presence on the surface, which

often consists of mounds or low hills more than 100 feet high. One of these

old valleys connects the Clyde near Dumbarton with the Forth at

Grangemouth, and appears to have contained two streams flowing in opposite

directions from a watershed about midway at Kilsith. At {337} Grangemouth

the old channel is 260 feet below the sea-level. The watershed at Kilsith

is now 160 feet above the sea, the old valley bottom being 120 feet deep or

forty feet above the sea. In some places the old valley was a ravine with

precipitous rocky walls, which have been found in mining excavations. Sir

A. Geikie, who has himself discovered many similar buried valleys, is of

opinion that "they unquestionably belong to the period of the boulder

clay."

We have here a clear proof that, when these rivers were formed, the land

must have stood in relation to the sea \_at least\_ 260 feet higher than it

does now, and probably much more; and this is sufficient to join England to

the continent. Supporting this evidence, we have freshwater or littoral

shells found at great depths off our coasts. Mr. Godwin Austen records the

dredging up of a freshwater shell (\_Unio pictorum\_) off the mouth of the

English Channel between the fifty fathom and 100 fathom lines, while in the

same locality gravel banks with littoral shells now lie under sixty or

seventy fathoms water.[81] More recently Mr. Gwyn Jeffreys has recorded the

discovery of eight species of fossil arctic shells off the Shetland Isles

in about ninety fathoms water, all being characteristic shallow water

species, so that their association at this great depth is a distinct

indication of considerable subsidence.[82]

\_Time of Last Union with the Continent.\_--The period when this last union

with the continent took place was comparatively recent, as shown by the

identity of the shells with living species, and the fact that the buried

river channels are all covered with clays and gravels of the glacial

period, of such a character as to indicate that most of them were deposited

above the sea-level. From these and various other indications geologists

are all agreed that the last continental period, as it is called, was

subsequent to the greatest development of the ice, but probably before the

cold epoch had wholly passed away. But if so recent, we should naturally

expect our land still {338} to show an almost perfect community with the

adjacent parts of the continent in its natural productions; and such is

found to be the case. All the higher and more perfectly organised animals

are, with but few exceptions, identical with those of France and Germany;

while the few species still considered to be peculiar may be accounted for

either by an original local distribution, by preservation here owing to

favourable insular conditions, or by slight modifications having been

caused by these conditions resulting in a local race, sub-species, or

species.

\_Why Britain is Poor in Species.\_--The former union of our islands with the

continent, is not, however, the only recent change they have undergone.

There have been partial submergences to the depth of from one hundred to

perhaps three hundred feet over a large part of our country; while during

the period of maximum glaciation the whole area north of the Thames was

buried in snow and ice. Even the south of England must have suffered the

rigour of an almost arctic climate, since Mr. Clement Reid has shown that

floating ice brought granite blocks from the Channel Islands to the coast

of Sussex. Such conditions must have almost exterminated our preexisting

fauna and flora, and it was only during the subsequent union of Britain

with the continent that the bulk of existing animals and plants could have

entered our islands. We know that just before and during the glacial period

we possessed a fauna almost or quite identical with that of adjacent parts

of the continent and equally rich in species. The glaciation and

submergence destroyed much of this fauna; and the permanent change of

climate on the passing away of the glacial conditions appears to have led

to the extinction or migration of many species in the adjacent continental

areas, where they were succeeded by the assemblage of animals now occupying

Central Europe. When England became continental, these entered our country;

but sufficient time does not seem to have elapsed for the migration 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.

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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. Germany, for example,

possesses nearly ninety species of land mammalia, and even Scandinavia

about sixty, while Britain has only forty, and Ireland only twenty-two. The

depth of the Irish Sea being somewhat greater than that of the German

Ocean, the connecting land would there probably be of small extent and of

less duration, thus offering an additional barrier to migration, whence has

arisen the comparative zoological poverty of Ireland. This poverty attains

its maximum in the reptiles, as shown by the following figures:--

Belgium has 22 species of reptiles and amphibia.

Britain ,, 13 ,, ,, ,,

Ireland ,, 4 ,, ,, ,,

Where the power of flight existed, and thus the period of migration was

prolonged, the difference is less marked; so that Ireland has seven bats to

twelve in Britain, and about 110 as against 130 land-birds.

Plants, which have considerable facilities for passing over the sea, are

somewhat intermediate in proportionate numbers, there being about 970

flowering plants and ferns in Ireland to 1,425 in Great Britain,--or almost

exactly two-thirds, a proportion intermediate between that presented by the

birds and the mammalia.

\_Peculiar British Birds.\_--Among our native mammalia, reptiles, and

amphibia, it is the opinion of the best authorities that we possess neither

a distinct species nor distinguishable variety. In birds, however, the case

is different, since some of our species, in particular our coal-tit and

long-tailed tit, present well-marked differences of colour as compared with

continental specimens; and in Mr. Dresser's work on the \_Birds of Europe\_

they are considered to be distinct species, while Professor Newton, in his

new edition of Yarrell's \_British Birds\_, does not consider the difference

to be sufficiently great or sufficiently constant to warrant this, and

therefore classes {340} them as insular races of the continental species.

We have, however, one undoubted case of a bird peculiar to the British

Isles, in the red grouse (\_Lagopus scoticus\_), which abounds in Scotland,

Ireland, the north of England, and Wales, and is very distinct from any

continental species, although closely allied to the willow grouse of

Scandinavia. This latter species resembles it considerably in its summer

plumage, but becomes pure white in winter; whereas our species retains its

dark plumage throughout the year, becoming even darker in winter than in

summer. We have here therefore a most interesting example of an insular

form in our own country; but it is difficult to determine how it

originated. On the one hand, it may be an old continental species which

during the glacial epoch found a refuge here when driven from its native

haunts by the advancing ice; or, on the other hand, it may be a descendant

of the Northern willow grouse, which has lost its power of turning white in

winter owing to its long residence in the lowlands of an island where there

is little permanent snow, and where assimilation in colour to the heather

among which it lurks is at all times its best protection. In either case it

is equally interesting, as the one large and handsome bird which is

peculiar to our islands notwithstanding their recent separation from the

continent.

The following is a list of the birds now held to be peculiar to the British

Isles:--

1. Parus ater, \_sub. sp.\_ BRITANNICUS Closely allied to \_P. ater\_ of

the continent; a local race or

sub-species.

2. Acredula caudata, \_sub. sp.\_ ROSEA Allied to \_A. caudata\_ of the

continent.

3. LAGOPUS SCOTICUS Allied to \_L. albus\_ of

Scandinavia, a distinct species.

\_Freshwater Fishes.\_--Although the productions of fresh waters have

generally, as Mr. Darwin has shown, a wide range, fishes appear to form an

exception, many of them being extremely limited in distribution. Some are

confined to particular river valleys or even to single rivers, others

inhabit the lakes of a limited district only, while some are {341} confined

to single lakes, often of small area, and these latter offer examples of

the most restricted distribution of any organisms whatever. Cases of this

kind are found in our own islands, and deserve our especial attention. It

has long been known that some of our lakes possessed peculiar species of

trout and charr, but how far these were unknown on the continent, and how

many of those in different parts of our islands were really distinct, had

not been ascertained till Dr. GÃ¼nther, so well known for his extensive

knowledge of the species of fishes, obtained numerous specimens from every

part of the country, and by comparison with all known continental species

determined their specific differences. The striking and unexpected result

has thus been attained, that no less than fifteen well-marked species of

freshwater fishes are altogether peculiar to the British Islands. The

following is the list, with their English names and localities:--[83]

\_Freshwater Fishes peculiar to the British Isles.\_

\_Latin Name.\_ | \_English Name.\_ | \_Locality.\_

| |

1. SALMO BRACHYPOMA |Short-headed salmon|Firth of Forth, Tweed,

| |Ouse.

| |

2. ,, GALLIVENSIS |Galway sea-trout |Galway, West Ireland.

| |

3. ,, ORCADENSIS |Loch Stennis trout |Lakes of Orkney.

| |

4. ,, FEROX |Great lake trout |Larger lakes of Scotland,

| |Ireland, the N. of England,

| |and Wales.

| |

5. ,, STOMACHICUS |Gillaroo trout |Lakes of Ireland.

| |

6. ,, NIGRIPINNIS |Black-finned trout |Mountain lochs of Wales

| |and Scotland.

| |

7. ,, LEVENENSIS |Loch Leven Trout |Loch Leven, Loch Lomond,

| |Windermere.

| |

8. ,, PERISII |Welsh charr |Llanberris lakes, N.

| |Wales.

| |

9. ,, WILLUGHBII |Windermere charr |Lake Windermere and

| |others in N. of England,

| |and Lake Bruiach in

| |Scotland.

| |

10. ,, KILLINENSIS |Lock Killin charr |Killin lake in

| |Inverness-shire.

| |

11. ,, COLII |Cole's charr |Lough Eske and Lough

| |Dan, Ireland.

| |

12. ,, GRAYI |Gray's charr |Lough Melvin, Leitrim,

| |N.W. Ireland.

| |

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13. COREGONUS CLUPEOIDES |The gwyniad, or |Loch Lomond, Ulleswater,

|schelly |Derwentwater,

| |Haweswater, and Bala

| |lake.

| |

14. ,, VANDESIUS |The vendace |Loch Maben, Dumfriesshire.

| |

15. ,, POLLAN |The pollan |Lough Neagh and Lough

| |Earne, N. of Ireland.

These fifteen peculiar fishes differ from each other and from all British

and continental species, not in colour only, but in such important

structural characters as the number and size of the scales, form and size

of the fins, and the form or proportions of the head, body, or tail. Some

of them, like \_S. killinensis\_ and the Coregoni are in fact, as Dr. GÃ¼nther

assures me, just as good and distinct species as any other recognised

species of fish. It may indeed be objected that, until all the small lakes

of Scandinavia are explored, and their fishes compared with ours, we cannot

be sure that we have any peculiar species. But this objection has very

little weight if we consider how our own species vary from lake to lake and

from island to island, so that the Orkney species is not found in Scotland,

and only one of the peculiar British species extends to Ireland, which has

no less than five species altogether peculiar to it. If the species of our

own two islands are thus distinct, what reason have we for believing that

they will be otherwise than distinct from those of Scandinavia? At all

events, with the amount of evidence we already possess of the very

restricted ranges of many of our species, we must certainly hold them to be

peculiar till they have been proved to be otherwise.

The great speciality of the Irish fishes is very interesting, because it is

just what we should expect on the theory of evolution. In Ireland the two

main causes of specific change--isolation and altered conditions--are each

more powerful than in Britain. Whatever difficulty continental fishes may

have in passing over to Britain, that difficulty will certainly be

increased by the second sea passage to Ireland; and the latter country has

been longer isolated, for the Irish Sea with its northern and southern

channels is considerably deeper than the German Ocean and the {343} Eastern

half of the English Channel, so that, when the last subsidence occurred,

Ireland would have been an island for some length of time while England and

Scotland still formed part of the continent. Again, whatever differences

have been produced by the exceptional climate of our islands will have been

greater in Ireland, where insular conditions are at a maximum, the

abundance of moisture and the equability of temperature being far more

pronounced than in any other part of Europe.

Among the remarkable instances of limited distribution afforded by these

fishes, we have the Loch Stennis trout confined to the little group of

lakes in the mainland of Orkney, occupying altogether an area of about ten

miles by three; the Welsh charr confined to the Llanberris lakes, about

three miles in length; Gray's charr confined to Lough Melvin, about seven

miles long; while the Loch Killin charr, known only from a small mountain

lake in Inverness-shire, and the vendace, from the equally small lakes at

Loch Maben in Scotland, are two examples of restricted distribution which

can hardly be surpassed.

\_Cause of Great Speciality in Fishes.\_--The reason why fishes alone should

exhibit such remarkable local modifications in lakes and islands is

sufficiently obvious. It is due to the extreme rarity of their transmission

from one lake to another. Just as we found to be the case in Oceanic

Islands, where the means of transmission were ample hardly any modification

of species occurred, while where these means were deficient and individuals

once transported remained isolated during a long succession of ages, their

forms and characters became so much changed as to bring about what we term

distinct species or even distinct genera,--so these lake fishes have become

modified because the means by which they are enabled to migrate so rarely

occur. It is quite in accordance with this view that some of the smaller

lakes contain no fishes, because none have ever been conveyed to them.

Others contain several; and some fishes which have peculiarities of

constitution or habits which render their transmission somewhat less

difficult occur in several lakes over a wide area of country, though only

one appears to be common to the British and Irish lakes. {344}

The manner in which fishes are enabled to migrate from lake to lake is

unknown, but many suggestions have been made. It is a fact that whirlwinds

and waterspouts sometimes carry living fish in considerable numbers and

drop them on the land. Here is one mode which might certainly have acted

now and then in the course of thousands of years, and the eggs of fishes

may have been carried with even greater ease. Again we may well suppose

that some of these fish have once inhabited the streams that enter or flow

out of the lakes as well as the lakes themselves; and this opens a wide

field for conjecture as to modes of migration, because we know that rivers

have sometimes changed their courses to such an extent as to form a union

with distinct river basins. This has been effected either by floods rising

over low watersheds, by elevations of the land changing lines of drainage,

or by ice blocking up valleys and compelling the streams to flow over

watersheds to find an outlet. This is known to have occurred during the

glacial epoch, and is especially manifest in the case of the Parallel Roads

of Glenroy, and it probably affords the true solution of many of the cases

in which existing species of fish inhabit distinct river basins whether in

streams or lakes. If a fish thus wandered out of one river-basin into

another, it might then retire up the streams to some of the lakes, where

alone it might find conditions favourable to it. By a combination of the

modes of migration here indicated it is not difficult to understand how so

many species are now common to the lakes of Wales, Cumberland, and

Scotland, while others less able to adapt themselves to different

conditions have survived only in one or two lakes in a single district; or

these last may have been originally identical with other forms, but have

become modified by the particular conditions of the lake in which they have

found themselves isolated.

\_Peculiar British Insects.\_--We now come to the class of insects, and here

we have much more difficulty in determining what are the actual facts,

because new species are still being yearly discovered and considerable

portions of Europe are but imperfectly explored. It often happens that an

insect is discovered in our islands, and for some {345} years Britain is

its only recorded locality; but at length it is found on some part of the

continent, and not unfrequently has been all the time known there, but

disguised by another name, or by being classed as a variety of some other

species. This has occurred so often that our best entomologists have come

to take it for granted that \_all\_ our supposed peculiar British species are

really natives of the continent and will one day be found there; and owing

to this feeling little trouble has been taken to bring together the names

of such as from time to time remain known from this country only. The view

of the probable identity of our entire insect-fauna with that of the

continent has been held by such well-known authorities as the late Mr.

E. C. Rye and Dr. D. Sharp for the beetles, and by Mr. H. T. Stainton for

butterflies and moths; but as we have already seen that among two orders of

vertebrates--birds and fishes--there are undoubtedly peculiar British

species, it seems to me that all the probabilities are in favour of there

being a much larger number of peculiar species of insects. In every other

island where some of the vertebrates are peculiar--as in the Azores, the

Canaries, the Andaman Islands, and Ceylon--the insects show an equal if not

a higher proportion of speciality, and there seems no reason whatever why

the same law should not apply to us. Our climate is undoubtedly very

distinct from that of any part of the continent, and in Scotland, Ireland,

and Wales we possess extensive tracts of wild mountainous country where a

moist uniform climate, an alpine or northern vegetation, and a considerable

amount of isolation, offer all the conditions requisite for the

preservation of some species which may have become extinct elsewhere, and

for the slight modification of others since our last separation from the

continent. I think, therefore, that it will be very interesting to take

stock, as it were, of our recorded peculiarities in the insect world, for

it is only by so doing that we can hope to arrive at any correct solution

of the question on which there is at present so much difference of opinion.

For the list of Coleoptera with the accompanying notes I was originally

indebted to the late Mr. E. C. Rye; and Dr. Sharp also gave me valuable

information as to the recent {346} occurrence of some of the supposed

peculiar species on the continent. The list has now been revised by the

Rev. Canon Fowler, author of the best modern work on the British

Coleoptera, who has kindly furnished some valuable notes.

For the Lepidoptera I first noted all the species and varieties marked as

British only in Staudinger's Catalogue of European Lepidoptera. This list

was carefully corrected by Mr. Stainton, who weeded out all the species

known by him to have been since discovered, and furnished me with valuable

information on the distribution and habits of the species. This information

often has a direct bearing on the probability of the insect being peculiar

to Britain, and in some cases may be said to explain why it should be so.

For example, the larvÃ¦ of some of our peculiar species of Tineina feed

during the winter, which they are enabled to do owing to our mild and

insular climate, but which the severer continental winters render

impossible. A curious example of the effect this habit may have on

distribution is afforded by one of our commonest British species,

\_Elachista rufocinerea\_, the larva of which mines in the leaves of \_Holcus

mollis\_ and other grasses from December to March. This species, though

common everywhere with us, extending to Scotland and Ireland, is quite

unknown in similar latitudes on the continent, but appears again in Italy,

the South of France, and Dalmatia, where the mild winters enable it to live

in its accustomed manner.

Such cases as this afford an excellent illustration of those changes of

distribution, dependent probably on recent changes of climate, which may

have led to the restriction of certain species to our islands. For should

any change of climate lead to the extinction of the species in South

Europe, where it is far less abundant than with us, we should have a common

and wide-spread species entirely restricted to our islands. Other species

feed in the larva state on our common gorse, a plant found only in limited

portions of Western and Southern Europe; and the presence of this plant in

a mild and insular climate such as ours may well be supposed to have led to

the preservation of some of the numerous species which are or have been

dependent on it. Since the first edition was {347} published many new

British species have been discovered, while some of the supposed peculiar

species have been found on the continent. Information as to these has been

kindly furnished by Mr. W. Warren, Mr. C. G. Barrett, Lord Walsingham, and

other students of British Lepidoptera, and the first-named gentleman has

also looked over the proofs.

Mr. McLachlan has kindly furnished me with some valuable information on

certain species of Trichoptera or Caddis flies which seem to be peculiar to

our islands; and this completes the list of orders which have been studied

with sufficient care to afford materials for such a comparison. We will now

give the list of peculiar British Insects, beginning with the Lepidoptera

and adding such notes as have been supplied by the gentlemen already

referred to.

\_List of the Species or Varieties of Lepidoptera which, so far as at

present known, are confined to the British Islands. (The figures show the

dates when the species was first described. Species added since the first

edition are marked with an asterisk.)\_

DIURNI.

1. POLYOMMATUS DISPAR. "The large copper." This fine insect, once

common in the fens, but now extinct owing to extensive drainage, is

generally admitted to be peculiar to our island, at all events as a

variety or local form. Its continental ally differs constantly in being

smaller and in having smaller spots; but the difference, though

constant, is so slight that it is now classed as a variety under the

name of \_rutilus\_. Our insect may therefore be stated to be a

well-marked local form of a continental species.

2. LycÃ¦na astrarche, \_var.\_ ARTAXERXES. This very distinct form is

confined to Scotland and the north of England. The species of which it

is considered a variety (more generally known to English entomologists

as \_P. agestis\_) is found in the southern half of England, and almost

everywhere on the continent.

BOMBYCES.

3. Lithosia complana, \_var.\_ SERICEA. North of England (1861).

4. Hepialus humuli, \_var.\_ HETHLANDICA. Shetland Islands (1865). A

remarkable form, in which the male is usually yellow and buff instead

of pure white, as in the common form, but exceedingly variable in tint

and markings.

5. EPICHNOPTERYX RETICELLA. Sheerness, Gravesend, and other localities

along the Thames (1847); Hayling Island, Sussex.

6. E. pulla, \_var.\_ RADIELLA. Near London, rare (1830?); the species in

Central and Southern Europe. (Doubtfully peculiar in Mr. Stainton's

opinion.) {348}

NOCTUÃ.

7. Acronycta euphorbiÃ¦, \_var.\_ MYRICÃ. Scotland only (1852). A melanic

form of a continental species.

8. AGROTIS SUBROSEA. Cambridgeshire and Huntingdonshire fens, perhaps

extinct (1835). The \_var.\_ \_subcÃ¦rulea\_ is found in Finland and

Livonia.

9. Agrotis candelarum \_var.\_ ASHWORTHII. South and West (1855).

Distinct and not uncommon.

10. Luperina luteago, \_var.\_ BARRETTI. Ireland (1864).

11. Aporophyla australis, \_var.\_ PASCUEA. South of England (1830). A

variety of a species otherwise confined to South Europe.

12. HydrÃ¦cia nictitans, \_var.\_ PALUDRIS.

GEOMETRÃ.

13. Boarmia gemmaria, \_var.\_ PERFUMARIA. Near London and elsewhere. A

large dark variety of a common species.

14. \*B. repandata, \_var.\_ SODORENSIUM. Outer Hebrides.

15. \*Emmelesia albulata, \_var.\_ HEBRIDIUM. Outer Hebrides.

16. \*E. albulata, \_var.\_ THULES. Shetland Islands.

17. \*Melanippe montanata, \_var.\_ SHETLANDICA. Shetland Islands.

18. \*M. sociata, \_var.\_ OBSCURATA. Outer Hebrides. A dark form.

19. Cidaria albulata, \_var.\_ GRISEATA. East of England (1835). A

variety of a species otherwise confined to Central and Southern Europe.

20. EUPITHECIA CONSTRICTATA.. Widely spread, but local (1835). Larva on

thyme.

21. \*E. satyrata, \_var.\_ CURZONI. N. Scotland.

22. \*E. nanata \_var.\_ CURZONI. Shetland Islands.

PYRALIDINA.

23. Aglossa pinguinalis, \_var.\_ STREATFIELDI. Mendip Hills (1830). A

remarkable variety of the common "tabby."

24. \*Scoparia cembrÃ¦, \_var.\_ SCOTICA. Scotland (1872).

25. \*Myelois ceratoniÃ¦, \_var.\_ PRYERELLA. North London (1871).

26. \*Howoeosoma nimbella, \_var.\_ SAXICOLA. England, Scotland, Isle of

Man (1871).

27. \*Epischnia bankesiella. Isle of Portland (1888).

TORTRICINA.

28. APHELIA NIGROVITTANA. Scotland (1852). A local form of the

generally distributed \_A. lanceolana\_.

29. GRAPHOLITA PARVULANA. Isle of Wight (1858). Rare. A distinct

species.

30. CONCHYLIS ERIGERANA. South-east of England (1866).

31. \*BRACHYTÃNIA WOODIANA. Herefordshire (1882).

32. \*Eupoecilia angustana, \_var.\_ THULEANA. Shetland Islands.

33. \*TORTRIX DONELANA. Connemara, Ireland (1890).

TINEINA.

34. TINEA COCHYLIDELLA. Sanderstead, near Croydon (1854). Unique!

35. ACROLEPIA BETULÃTELLA. Yorkshire and Durham (1840). Rare.

36. ARGYRESTHIA SEMIFUSCA. North and West of England (1829). Rather

scarce. A distinct species.

37. GELECHIA DIVISELLA. A fen insect (1856). Rare. {349}

38. G. CELERELLA. West of England (1854). A doubtful species.

39. \*G. TETRAGONELLA. Yorkshire. Norfolk. Salt marshes.

40. \*G. SPARSICILIELLA. Pembroke.

41. \*G. PLANTAGINELLA. A salt-marsh species.

42. G. OCELLATELLA (Barrett \_nec\_ Stainton). Bred from \_Beta maritima\_.

Very distinct.

43. BRYOTROPHA POLITELLA. Moors of North of England. Norfolk (1854).

44. \*B. PORTLANDICELLA. Isle of Portland (1890).

45. LITA FRATERNELLA. Widely scattered (1834). Larva feeds on shoots of

\_Stellaria uliginosa\_ in spring.

46. L. BLANDULELLA. Kent.

47. ANACAMPSIS SIRCOMELLA. North and West England (1854). Perhaps a

melanic variety of the more widely spread \_A. tÃ¦niolella\_.

48. A. IMMACULATELLA. West Wickham (1834). Unique! A distinct species.

49. \*OECOPHORA WOODIELLA?

50. GLYPHIPTERYX CLADIELLA. Eastern Counties (1859). Abundant.

51. G. SCHOENICOLELLA. In several localities (1859).

52. GRACILARIA STRAMINEELLA. (1850). On birch. Perhaps a local form of

\_G. elongella\_, found on alder.

53. ORNIX LOGANELLA. Scotland (1848). Abundant, and a distinct species.

54. O. DEVONIELLA. In Devonshire (1854). Unique!

55. COLEOPHORA SATURATELLA. South of England (1850). Abundant on broom.

56. C. INFLATÃ. South and East of England. On \_Silene inflata.\_ ?

continental.

57. C. SQUAMOSELLA. Surrey (1856). Very rare, but an obscure species.

58. C. SALINELLA. On Sea-coast (1859). Abundant.

59. \*C. POTENTILLÃ. South of England.

60. \*C. ADJUNCTELLA. Essex salt marshes. ? Lancashire (1882).

61. \*C. LIMONIELLA. Isle of Wight. Feeds on \_Statice limonium\_.

62. ELACHISTA FLAVICOMELLA. Dublin (1856). Excessively rare, two

specimens only known.

63. \*E. SCIRPI. Wales and Sussex. Salt marshes.

64. E. CONSORTELLA. Scotland (1854). A doubtful species.

65. E. MEGERLELLA. Widely distributed (1854). Common. Larva feeds in

grass during winter and early spring.

66. E. OBLIQUELLA. Near London (1854). Unique!

67. E. TRISERIATELLA. South of England (1854). Very local; an obscure

species.

68. \*TINAGMA BETULÃ. East Dorset (1891).

69. LITHOCOLLETIS NIGRESCENTELLA. Northumberland (1850). Rare; a dark

form of \_L. Bremiella\_, which is widely distributed.

70. \*L. ANDERIDÃ. Sussex. Dorset (1886).

71. L. IRRADIELLA. North Britain (1854). A northern form of the more

southern and wide-spread \_L. lautella\_.

72. L. TRIGUTTELLA. Sanderstead, near Croydon (1848). Unique! very

peculiar.

73. L. ULICICOLELLA. In a few wide-spread localities (1854). A peculiar

form.

74. L. CALEDONIELLA. North Britain (1854). A local variety of the more

widespread \_L. corylifoliella\_. {350}

75. L. DUNNINGIELLA. North of England (1852). A somewhat doubtful

species.

76. BUCCULATRIX DEMARYELLA. Widely distributed (1848). Rather common.

77. TRIFURCULA SQUAMATELLA. South of England (1854). A doubtful

species.

78. NEPTICULA IGNOBILIELLA. Widely scattered (1854). On hawthorn, not

common. ? on continent.

79. N. POTERII. South of England (1858). Bred from LarvÃ¦ in \_Poterium

sanguisorba\_.

80. N. QUINQUELLA. South of England (1848). On oak leaves, very local.

? continental.

81. N. APICELLA. Local (1854). Probably confused with allied species on

the continent.

82. N. HEADLEYELLA. Local (1854). A rare species.

83. \*N. HODGKINSONI. Lancashire.

84. \*N. WOOLHOPIELLA. Herefordshire.

85. \*N. SERELLA. Westmoreland and S. England.

86. \*N. AUROMARGINELLA. Dorset (1890).

87. \*MICROPTERYX SANGII. (1891).

88. \*M. SALOPIELLA.

PTEROPHORINA.

89. AGDISTIS BENNETTI. East coast. I. of Wight (1840). Common on

\_Statice limonium\_.

We have here a list of eighty-nine species, which, according to the best

authorities, are, in the present state of our knowledge, peculiar to

Britain. It is a curious fact that no less than fifty of these have been

described more than twenty-five years; and as during all that time they

have not been recognised on the continent, notwithstanding that good

coloured figures exist of almost all of them, it seems highly probable that

many of them are really confined to our island. At the same time we must

not apply this argument too rigidly, for the very day before my visit to

Mr. Stainton he had received a letter from Professor Zeller announcing the

discovery on the continent of a species of our last family, Pterophorina,

which for more than forty years had been considered to be exclusively

British. This insect, \_Platyptilia similidactyla\_ (\_Pterophorus

isodactylus\_, Stainton's \_Manual\_), had been taken rarely in the extreme

north and south of our islands--Teignmouth and Orkney, a fact which seemed

somewhat indicative of its being a straggler. Again, seven of the species

are unique, that is, have only been captured once; and it may be supposed

that, as they are so rare as to have been found only once in England, they

may be all {351} equally rare and not yet found on the continent. But this

is hardly in accordance with the laws of distribution. Widely scattered

species are generally abundant in some localities; while, when a species is

on the point of extinction, it must for a time be very rare in the single

locality where it last maintains itself. It is then more probable that some

of these unique species represent such as are almost extinct, than that

they have a wide range and are equally rare everywhere; and the peculiarity

of our insular climate, combined with our varied soil and vegetation, offer

conditions which may favour the survival of some species with us after they

have become extinct on the continent.

Of the sixty-nine species recorded in my first edition fourteen have been

since discovered on the continent, while no less than twenty-two species

and eleven varieties have been added to the list. As we can hardly suppose

continental entomologists to be less thorough collectors than ourselves, it

ought to be more and more difficult to find any insects which are unknown

on the continent if all ours really exist there; and the fact that the list

of apparently peculiar British species is an increasing one renders it

probable that many of them are not only apparently but really so. Both

general considerations dependent on the known laws of distribution, and the

peculiar habits, conspicuous appearance, and restricted range, of many of

our species, alike indicate that some considerable proportion of them will

remain permanently as peculiar British species.

We will now pass on to the Coleoptera, or beetles, an order which has been

of late years energetically collected and carefully studied by British

entomologists.

\_List of the Species and Varieties of Beetles which, so far as at present

known, are confined to the British Islands. Those added since the first

edition are marked with an asterisk.\_

CARABIDÃ.

1. \*Bembidium saxatile, \_var.\_ VECTENSIS (Fowler). Isle of Wight.

2. DROMIUS VECTENSIS (Rye). Common in the Isle of Wight, also in Kent,

and at Weymouth and Seaton. Closely allied to \_D. sigma\_.

3. Harpalus latus, \_var.\_ METALLESCENS (Rye). Unique, but very marked!

South coast. "Perhaps a sport or a hybrid" (Fowler).

4. ACUPALPUS DERELICTUS (Dawson). Unique! North Kent. Canon Fowler

thinks it may be a variety of \_A. dorsalis\_. {352}

DYTICIDÃ.

5. \*Acilius sulcatus, \_var.\_ SCOTICUS (Curtis). Scotland. A melanic

variety.

HELOPHORIDÃ.

6. OCHTHEBIUS POWERI (Rye). Very marked. S. coast. A few specimens

only.

7. \*O. ÃNEUS (Steph).

BRACHYELYTRA.

8. OCYUSA HIBERNICA (Rye). Ireland, mountain tops, and at Braemar.

9. \*OXYPODA TARDA (Sharp).

10. ,, PECTITA (Sharp). Scotland.

11. ,, VERECUNDA (Sharp). Scotland, also London districts.

12. HOMALOTA DIVERSA (Sharp).

13. ,, FULVIPENNIS (Rye).

14. ,, OBLONGIUSCULA (Sharp). Scotland, also England and Ireland.

15. ,, PRINCEPS (Sharp). A coast insect.

16. ,, CURTIPENNIS (Sharp). Scotland and near Birmingham.

17. H. levana, \_var.\_ SETIGERA (Sharp).

18. STENUS OSCILLATOR (Rye). Unique! South coast. May be a hybrid.

19. TROGOPHLÃUS SPINICOLLIS (Rye). Mersey estuary, unique! Most

distinguishable, nothing like it in Europe. Perhaps imported from

another continent.

20. EUDECTUS WHITEI (Sharp). Scotch hills. A variety of \_E. Giraudi\_ of

Germany (the only European species) \_fide\_ Kraatz (Sharp).

21. HOMALIUM RUGULIPENNE (Rye). Exceedingly marked form. Northern and

western coasts; rare.

22. \*MYCETOPORUS MONTICOLA (Fowler). Cheviots and Inverness-shire.

SCYDMÃNIDÃ.

23. \*SCYDMÃNUS POWERI (Fowler) S. England. A recent discovery.

24. \*S. PLANIFRONS (Fowler). ,, ,,

PSELAPHIDÃ.

25. BRYAXIS COTUS (De Sauley). Scotland.

26. BYTHINUS GLABRATUS (Rye). Sussex coast; also Isle of Wight; a few

specimens; very distinguishable; myrmecophilous (lives in ants' nests).

TRICHOPTERYGIDÃ.

27. PTINELLA MARIA (Matthews) Derbyshire.

28. TRICHOPTERYX SARÃ ( ,, ) Notts.

29. ,, POWERI ( ,, ) Oxon.

30. ,, EDITHIA ( ,, ) Kent.

31. ,, \*ANGUSTA ( ,, ) Leicestershire.

32. ,, KIRBII ( ,, ) Norfolk.

33. ,, FRATERCULA ( ,, )

34. ,, WATERHOUSII ( ,, )

35. ,, CHAMPIONIS ( ,, ) Wicken Fen.

36. ,, JANSONI ( ,, ) Leicestershire.

37. ,, SUFFOCATA (Haliday). Ireland, Co. Cork.

38. ,, CARBONARIA (Matthews). Notts.

{353} 39. Ptilium halidayi (Matthews). Sherwood Forest.

40. ,, caledonicum (Sharp). Scotland; very marked form.

41. ,, insigne (Matthews). London district.

42. \*ORTHOPERUS MUNDUS (Matthews). Oxfordshire.

43. \*O. PUNCTULATUS (Matthews). Lincolnshire.

ANISOTOMIDÃ.

44. AGATHIDIUM RHINOCEROS (Sharp). Old fir-woods in Perthshire; local,

many specimens; a very marked species.

45. ANISOTOMA SIMILATA (Rye). South of England. Two specimens.

46. ,, LUNICOLLIS (Rye). North-east and South of England, a very

marked form; several specimens.

PHALACRIDÃ.

47. PHALACRUS BRISOUTI (Rye). South of England. Rare. "Perhaps a small

form of \_P. coruscus\_" (Fowler).

CRYPTOPHAGIDÃ.

48. ATOMARIA DIVISA (Rye). Unique! South of England.

LATHRIDIIDÃ.

49. Melanopthalma transversalis, \_var.\_ WOLLASTONI (Waterhouse). South

coast, and Lincolnshire.

BYRRHIDÃ.

50. SYNCALYPTA HIRSUTA (Sharp). South of England, local. "Closely

allied to \_S. setigera\_" (Fowler).

MORDELLIDÃ.

51. \*ANASPIS SEPTENTRIONALIS. Scotland (1891). (Champion.)

52. \* ,, GARNEYSI (Fowler). London District. (1890.)

TELEPHORIDÃ.

53. TELEPHORUS DARWINIANUS (Sharp). Scotland, sea-coast. A stunted form

of abnormal habits. Perhaps a variety of \_T. lituratus\_.

CYPHONIDÃ.

54. CYPHON PUNCTIPENNIS (Sharp). Scotland.

ANTHICIDÃ.

55. ANTHICUS SALINUS (Crotch). South coast.

56. ,, SCOTICUS (Rye). Loch Leven; very distinct; many specimens.

CIOIDÃ.

57. \*CIS BILAMELLATUS (Wood). West Wickham, Kent. "Perhaps imported.

Has the appearance of an exotic Cis" (Fowler).

TOMICIDÃ.

58. \*Pityopthorus lichtensteinii, \_var.\_ SCOTICUS (Blandford).

Scotland.

CURCULIONIDÃ.

59. Ceuthorhynchus contractus, \_var.\_ PALLIPES (Crotch). Lundy Island;

several specimens. A curious variety only known from this island.

60. LIOSOMUS TROGLODYTES (Rye). A very queer form. Two or three

specimens. South of England.

61. \*Orcheites ilicis, \_var.\_ NIGRIPES (Fowler). London District.

(1890.)

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62. APION RYEI (Blackburn). Shetland Islands. Several specimens.

Perhaps a \_var.\_ of \_A. fagi\_.

CHRYSOMELIDÃ.

63. Chrysomela staphylea, \_var.\_ SHARPI (Fowler). Solway district.

HALTICIDÃ.

64. LONGITARSUS AGILIS (Rye). South of England; many specimens.

65. ,, DISTINGUENDA (Rye). South of England; many specimens.

66. PSYLLIODES LURIDIPENNIS (Kutschera). Lundy Island. A very curious

form, not uncommon in this small island, to which it appears to be

confined. "An extreme and local variety of \_P. chrysocephala\_"

(Fowler).

COCCINELLIDÃ.

67. SCYMNUS LIVIDUS (Bold). Northumberland. A doubtful species.

Of the sixty-seven species and varieties of beetles in the preceding list,

a considerable number no doubt owe their presence there to the fact that

they have not yet been discovered or recognised on the continent. This is

almost certainly the case with many of those which have been separated from

other species by very minute and obscure characters, and especially with

the excessively minute TrichopterygidÃ¦ described by Mr. Matthews. There are

others, however, to which this mode of getting rid of them will not apply,

as they are so marked as to be at once recognised by any competent

entomologist, and often so plentiful that they can be easily obtained when

searched for. The peculiar species of Apion in the Shetland Islands is

interesting, and may be connected with the very peculiar climatal

conditions there prevailing, which have led in some cases to a change of

habits, so that a species of weevil (\_Otiorhynchus maurus\_) always found on

mountain sides in Scotland here occurs on the sea-shore. Still more curious

is the occurrence of two distinct forms (a species and a well-marked

variety) on the small granitic Lundy Island in the Bristol Channel. This

island is about three miles long and twelve from the coast of Devonshire,

consisting mainly of granite with a little of the Devonian formation, and

the presence here of peculiar insects can only be due to isolation with

special conditions, and immunity from enemies or competing forms. When we

consider the similar islands off {355} the coast of Scotland and Ireland,

with the Isle of Man and the Scilly Islands, none of which have been yet

thoroughly explored for beetles, it is probable that many similar examples

of peculiar isolated forms remain to be discovered.

Looking, then, at what seem to me the probabilities of the case from the

standpoint of evolution and natural selection, and giving due weight to the

facts of local distribution as they are actually presented to us, I am

forced to differ from the opinion held by our best entomological

authorities, and to believe that some at least, perhaps many, of the

species which, in the present state of our knowledge, appear to be peculiar

to our islands, are, not only apparently, but really, so peculiar.

I am indebted to Mr. Robert McLachlan for the following information on

certain Trichopterous Neuroptera (or caddis-flies) which appear to be

confined to our islands. The peculiar aquatic habits of the larvÃ¦ of these

insects, some living in ponds or rivers, others in lakes, and others again

only in clear mountain streams, render it not improbable that some of them

should have become isolated and preserved in our islands, or that they

should be modified owing to such isolation.

\_Trichoptera peculiar to the British Isles.\_

1. PHILOPOTAMUS INSULARIS. (? A variety of \_P. montanus\_.)--This can

hardly be termed a British species or variety, because, so far as at

present known, it is peculiar to the Island of Guernsey. It agrees

structurally with \_P. montanus\_, a species found both in Britain and on

the continent, but it differs in its strikingly yellow colour, and less

pronounced markings. All the specimens from Guernsey are alike, and

resident entomologists assured Mr. McLachlan that no other kind is

known. Strange to say, some examples from Jersey differ considerably,

resembling the common European and British form. Even should this

peculiar variety be at some future time found on the continent it would

still be a remarkable fact that the form of insect inhabiting two small

islands only twenty miles apart should constantly differ; but as Jersey

is between Guernsey and the coast, it seems just possible that the more

insular conditions, and perhaps some peculiarity of the soil and water

in the former island, have really led to the production or preservation

of a well-marked variety of insect. In the first edition of this work

two other species were named as then, peculiar to Britain--Setodes

argentipunctella and Rhyacophila munda, but both have now been taken on

the continent.

2. MESOPHYLAX IMPUNCTATUS, \_var.\_ ZETLANDICUS.--A variety of a South

and Central European species, one specimen of which has been found in

Dumfriesshire. The variety is distinguished by its small size and dark

colour.

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\_Land and Freshwater Shells.\_--In the first edition of this work four

species were noted as being, so far as was then known, exclusively British.

Two of these, \_Cyclas pisidioides\_ (now called \_SphÃ¦rium pisidioides\_) and

\_Geomalacus maculosus\_, have been discovered on the continent, but the

other two remain still apparently confined to these islands; and to these

another has been added by the discovery of a new species of Hydrobia in the

estuary of the Thames. The peculiar species now stands as follows:--

1. LIMNEA INVOLUTA.--A pond snail with a small polished amber-coloured

shell found only in a small alpine lake and its inflowing stream on

Cromagloun mountain near the lakes of Killarney. It was discovered in

1838, and has frequently been obtained since in the same locality. It

is sometimes classed as a variety of \_Limnea peregra\_, and is at all

events closely allied to that species.

2. HYDROBIA JENKINSII.--A small shell of the family RissoidÃ¦ inhabiting

the Thames estuary both in Essex and Kent. It was discovered only a few

years ago, and was first described in 1889.

3. ASSIMINEA GRAYANA.--A small estuarine pulmonobranch found on the

banks of the Thames between Greenwich and Gravesend, on mud at the

roots of aquatic plants. It has been discovered more than sixty years.

But besides the above-named species there are a considerable number of

well-marked varieties of shells which seem to be peculiar to our islands. A

list of these has been kindly furnished me by Mr. Theo. D. A. Cockerell,

who has paid much attention to the subject; and after omitting all those

whose peculiarities are very slight or whose absence from the continent is

doubtful, there remain a series of forms some of which are in all

probability really endemic with us. This is the more probable from the fact

that an introduced colony of \_Helix nemoralis\_ at Lexington, Virginia,

presents numerous varieties among which are several which do not occur in

Europe.[84] The following list is therefore given in the hope that it may

be useful in calling attention to those varieties which are not yet

positively known to occur elsewhere than in our islands, and {357} thus

lead, ultimately, to a more accurate knowledge of the facts. It is only by

obtaining a full knowledge of varieties, their distribution and their

comparative stability, that we can ever hope to detect the exact process by

which nature works in the formation of species.

LIST OF THE SPECIES AND VARIETIES OF LAND AND FRESHWATER SHELLS WHICH, SO

FAR AS AT PRESENT KNOWN, ARE BELIEVED TO BE PECULIAR TO THE BRITISH ISLES

OR NOT FOUND ON THE CONTINENT.

LIMACIDÃ.

1. Limax marginatus, \_var.\_ MACULATUS. Ireland; frequent, very

distinct.

2. ,, ,, ,, DECIPIENS. Ireland and England.

3. ,, flavus, \_var.\_ SUFFUSUS. England; Melanic form.

4. ,, ,, ,, GRISEUS. England; Melanic form.

5. Agriolimax agrestis, \_var.\_ NIGER. Yorkshire. Melanic. Azores.

6. ,, ,, ,, GRISEUS. England. Melanic.

7. Amalia gagates, \_var.\_ RAVA. W. of England.

8. ,, sowerbyi, \_var.\_ RUSTICA. England.

9. ,, ,, ,, NIGRESCENS. Surrey and Middlesex.

10. ,, ,, ,, BICOLOR. Ealing.

11. Hyalina crystallina, \_var.\_ COMPLANATA. Near Bristol.

12. ,, fulva, \_var.\_ ALDERI.

13. Vitrina pellucida, \_var.\_ DEPRESSIUSCULA. S. England, Wales.

HELICIDÃ.

14. Arion ater, \_var.\_ ALBO-LATERALIS. England, Wales, Isle of Man;

very distinct.

15. ,, hortensis, \_var.\_ FALLAX. England. Common at Boxhill.

16. GEOMALACUS MACULOSUS. Kerry and Cork. Three varieties have been

described, one of which occurs in Portugal.

17. Helix aspersa, \_var.\_ LUTESCENS. England. Not rare perhaps in

France.

18. ,, nemoralis, \_var.\_ HIBERNICA. Ireland.

19. ,, rufescens, \_var.\_ MANCHESTERIENSIS. England.

20. ,, hispida, \_var.\_ SUBGLOBOSA. England.

21. ,, ,, ,, DEPILATA. England.

22. ,, ,, ,, MINOR. England, Ireland.

23. ,, granulata, \_var.\_ CORNEA. Lulworth, Dorset.

24. ,, virgata, \_var.\_ SUBAPERTA. Bath.

25. ,, ,, ,, SUBGLOBOSA. England, Wales, Bantry Bay.

26. ,, ,, ,, CARINATA. Wareham, Dorset.

27. ,, caperata, \_var.\_ MAJOR. England, Wales, Scotland. Distinct.

28. ,, ,, ,, NANA. England.

29. ,, ,, ,, SUBSCALARIS. Wales, Ireland.

30. ,, ,, ,, ALTERNATA. England, Kent.

31. ,, acuta, \_var.\_ NIGRESCENS. England.

PUPIDÃ.

32. Pupa anglica, \_var.\_ PALLIDA. Not rare.

33. ,, lilljeborgi, \_var.\_ BIDENTATA. Ireland.

{358} 34. ,, pygmea, \_var.\_ PALLIDA. Dorset and Devon.

35. Clausilia rugosa, \_var.\_ PARVULA. Ireland.

STENOGYRIDÃ.

36. Cochlicopa lubrica, \_var.\_ HYALINA. Wales, Scotland.

37. Coecilianella acicula, \_var.\_ ANGLICA. England.

SUCCINEIDÃ.

38. Succinea putris, \_var.\_ SOLIDULA. Wiltshire.

39. ,, virescens, \_var.\_ AUREA. Ireland.

40. ,, pfeifferi, ,, RUFESCENS. England, Ireland.

41. ,, ,, ,, MINOR. England.

LIMNÃIDÃ.

42. Planorbis fontanus, \_var.\_ MINOR. England.

43. ,, carinatus, ,, DISCIFORMIS. England.

44. ,, contortus, ,, EXCAVATUS. Ireland.

45. ,, ,, ,, MINOR.

46. Physa fontinalus, \_var.\_ OBLONGA. England, Wales, Ireland.

47. LIMNÃA INVOLUTA. Ireland.

48. LimnÃ¦a glutinosa, \_var.\_ MUCRONATA.

49. ,, peregra, \_var.\_ BURNETTI. Scotland. Very distinct.

50. ,, ,, ,, LACUSTRIS. Perhaps in C. Verde Islands.

51. ,, ,, ,, MARITIMA. Great Britain.

52. ,, ,, ,, LINEATA. England.

53. ,, ,, ,, STAGNALIFORMIS. England.

54. ,, stagnalis, \_var.\_ ELAGANTULA. Curious. In a pond at

Chislehurst.

55. ,, palustris, \_var.\_ CONICA. England, Ireland.

56. ,, ,, ,, TINCTA. England, Wales.

57. ,, ,, ,, ALBIDA. England.

58. ,, truncatula, \_var.\_ ELEGANS. England, Ireland. Distinct.

59. ,, ,, ,, FUSCA. Wales.

60. Ancylus lacustris, \_var.\_ COMPRESSUS. England.

PALUDINIDÃ.

61. Paludina vivipara, \_var.\_ EFASCIATA. England. Not uncommon.

62. ,, ,, ,, ATROPURPUREA. Pontypool.

RISSOIDÃ.

63. HYDROBIA JENKINSII. Thames Estuary.

64. ,, ventrosa, \_var.\_ MINOR.

65. ,, ,, ,, DECOLLATA.

66. ,, ,, ,, OVATA.

67. ,, ,, ,, ELONGATA.

68. ,, ,, ,, PELLUCIDA.

CYRENIDÃ.

69. SphÃ¦rium corneum, \_var.\_ COMPRESSUM.

70. ,, ,, ,, MINOR.

71. ,, ,, ,, STAGNICOLA.

72. ,, ovale, \_var.\_ PALLIDUM. England.

73. ,, lacustre, \_var.\_ ROTUNDUM. Wales.

74. Pisidium pusillum, \_var.\_ GRANDIS.

75. ,, ,, ,, CIRCULARE. Wales.

76. ,, nitidum, \_var.\_ GLOBOSUM.

{359} UNIONIDÃ.

77. Unio tumidus, \_var.\_ RICHENSIS. Regent's Park. Peculiar form.

78. ,, pictorum, \_var.\_ LATIOR. England.

79. ,, ,, ,, COMPRESSUS. England.

80. ,, margaritifer, \_var.\_ OLIVACEUS.

81. Anodonta cygnÃ¦a, \_var.\_ INCRASSATA. England.

82. ,, ,, ,, PALLIDA. England, Ireland.

ESTUARINE OR MARINE PULMONOTRANCHS.

83. ASSIMINEA GRAYANA. Thames Estuary.

\_Peculiarities of the British Flora.\_--Thinking it probable that there must

also be some peculiar British plants, but not finding any enumeration of

such in the \_British Floras\_ of Babington, Hooker, or Bentham, I applied to

the greatest living authority on the distribution of British plants--the

late Mr. H. C. Watson, who very kindly gave me the information I required,

and I cannot do better than quote his words: "It may be stated pretty

confidently that there is no 'species' (generally accepted among botanists

as a good species) peculiar to the British Isles. True, during the past

hundred years, nominally new species have been named and described on

British specimens only, from time to time. But these have gradually come to

be identified with species described elsewhere under other names--or they

have been reduced in rank by succeeding botanists, and placed or replaced

as varieties of more widely distributed species. In his \_British Rubi\_

Professor Babington includes as good species, some half-dozen which he has,

apparently, not identified with any foreign species or variety. None of

these are accepted as 'true species,' nor even as 'sub-species' in the

\_Students' Flora\_, where the brambles are described by Baker, a botanist

well acquainted with the plants of Britain. And as all these nominal

species of Rubi are of late creation, they have truly never been subjected

to real or critical tests as 'species.'"

In my first edition I was only able to name four species, sub-species, or

varieties of flowering plants which were believed to be unknown on the

continent. But much attention has of late years been paid to the critical

examination of British plants in comparison with continental specimens, and

I am now enabled to give a much more {360} extensive list of the species or

forms which at present seem to be peculiar. For the following list I am

primarily indebted to Mr. Arthur Bennett of Croydon. Sir Joseph Hooker has

been so kind as to examine it carefully and to give me his conclusions on

the relative value of the differences of the several forms, and Mr. Baker,

of Kew, has also assisted with his extensive knowledge of British plants.

LIST OF SPECIES, SUB-SPECIES, AND VARIETIES OF FLOWERING PLANTS FOUND

IN GREAT BRITAIN OR IRELAND, BUT NOT AT PRESENT KNOWN IN CONTINENTAL

EUROPE. BY ARTHUR BENNETT, F.L.S. THE MOST DISTINCT AND BEST DETERMINED

FORMS ARE MARKED WITH AN ASTERISK.

1. \*Caltha radicans (Forst.). "A much disputed species, or form of \_C.

palustris\_. It is a relatively rare plant." (J. D. H.) "Certainly

distinct from the Scandinavian form." (Ar. Bennett.)

2. \*Arabis petrÃ¦a (Lam.) \_var.\_ grandifolia (Druce). Scotch mountains.

"The larger flowers alone distinguish this." (J. D. H.)

3. Arabis ciliata (R. Br.). In Nyman's \_Conspectus FlorÃ¦ EuropÃ¦Ã¦\_ this

species is given as found in England and Ireland only. "A very much

disputed form of a plant of very wide distribution in Europe and North

America." (J. D. H.)

4. Brassica monensis (Huds.). "This and the continental \_B.

cheiranthus\_ (also found in Cornwall) are barely distinguishable from

one another." (J. D. H.)

5. Diplotaxis muralis (D. C.) \_var.\_ Babingtonii (Syme). South of

England. "A biennial or perennial form; considered to be a denizen by

Watson." (J. D. H.)

6. \*Helianthemum guttatum (Mill), \_var.\_ Breweri (Planch). Anglesea.

"Very doubtful local plant. \_H. guttatum\_ (true) has lately been found

in the same locality." (J. D. H.)

7. \*Polygala vulgaris (L.), \_var.\_ grandiflora (Bab). Sligo, Ireland.

"A very distinct variety." (J. D. H.)

8. Viola lutea (Huds.), \_var.\_ amoena (Symons). "\_V. lutea\_ itself is

considered to be a form of \_V. tricolor\_, and \_V. amoena\_ the better

coloured of the two forms of \_V. lutea\_." (J. D. H.)

9. \*Cerastium arcticum (Lange), \_var.\_ Edmonstonii (Beeby). Shetland

Is. "But \_C. arcticum\_ is referable to the very variable \_C. alpinum\_."

(J. D. H.) "Near to the European \_C. latifolium\_." (Ar. Bennett.)

10. \*Geranium sanguineum (L.), \_var.\_ Lancastriense (With.).

Lancashire. "A prostrate local form growing out of its native soil in

sand by the sea." (J. D. H.) Mr. Bennett writes: "I have grown \_G.

sanguineum\_ and its prostrate variety in sand, and neither became

Lancastriense."

11. Genista tinctoria (L.), \_var.\_ humifusa (Dickson). Cornwall. "A

decumbent hairy form confined to the Lizard." (J. D. H.)

12. Cytisus scoparius (Link.), \_var.\_ prostratus (Bailey). Cornwall. "A

prostrate form." (J. D. H.)

13. Anthyllis vulneraria (L.), \_var.\_ ovata (Bab.). Shetland Is. "A

slight variety." (J. D. H.)

14. \*Trifolium repens (L.), \_var.\_ Townsendii (Bab.). Scilly Isles. "A

{361} well-marked form by its rose-purple flowers. Confined to the

Scilly Isles." (J. D. H.)

15. \*Rosa involuta (Sm.), \_var.\_ Wilsoni. (Borrer.) Wales. "There are a

multitude of forms or varieties of \_R. involuta\_, and \_R. wilsoni\_ is

one of the best-marked, found on the Menai Straits and Derry."

(J. D. H.)

16. Rosa involuta \_var.\_ gracilis (Woods). "This is considered by many

as one of the commonest forms of \_R. involuta\_." (J. D. H.)

17. Rosa involuta \_var.\_ Nicholsoni (Crepin). "Another slight variety

of \_R. involuta\_." (J. D. H.)

18. Rosa involuta \_var.\_ Woodsiana (Groves). "A Wimbledon Common

variety of \_R. villosa\_." (J. D. H.)

19. Rosa involuta \_var.\_ Grovesii (Baker). "Mr. Baker thinks this of no

account." (J. D. H.)

20. Rubus echinatus (Lind.). "A variety of the widely spread \_R.

Radula\_, itself a form of \_R. fruticosus\_." (J. D. H.)

21. \*Rubus longithyrsiger (Lees). "Mr. Baker informs me that this is a

very distinct plant never yet found on the continent." (J. D. H.)

22. Pyrus aria (Sm.) \_var.\_ rupicola (Syme). "A very local form,

confined to Gt. Britain, and owing its characters to its starved

position." (Baker.)

23. Callitriche obtusangula (Le Gall), \_var.\_ Lachii (Warren).

Cheshire. "This is intermediate between two sub-species of \_C. verna\_."

(J. D. H.)

24. \*Oenanthe fluviatilis (Coleman). South of England. "The fluitant

form of \_Ã. Phellandrium\_." (J. D. H.)

25. Anthemis arvensis (L.), \_var.\_ anglica (Spreng). N. Coast of

England. "A maritime form with more fleshy leaves formerly found near

Durham. It has other very trifling characters." (J. D. H.)

26. Arctium intermedium (Bab.). "There are two sub-species of \_A.

lappa\_, \_majus\_ and \_minus\_, each with varieties, and this is one of

the intermediates." (J. D. H.)

27. Hieracium holosericium (Backh.). Scotch Alps.

28. H. gracilentum (Backh.). ,,

29. H. lingulatum (Backh.). ,, A var. of this in

Scandinavia.

30. H. senescens (Backh.). ,,

31. H. chrysanthenum (Backh.). ,,

32. H. iricum (Fr.). Teesdale and Scotland.

33. H. gibsoni (Backh.). Yorkshire and Westmoreland.

34. Hieracium nitidum (Backh.). Lower glens of the Scotch Alps. Mr.

Bennett writes:--"The following Hieracia have been named by Mr. F. J.

Hanbury \_as endemic forms\_. One can only safely say they are certainly

not known in Scandinavia, as they have all been submitted to Dr.

Lindeberg. But usually Scotch species are not represented in Central

Europe to any great extent, though several do occur. Still these new

forms ought to be critically compared with all Dr. Peters' new

species."

35. H. Langewellense (Hanb.). Caithness.

36. H. pollinarium (Hanb.). Sutherland.

37. H. scoticum (Hanb.). Sutherland and Caithness.

38. H. Backhousei (Hanb.). Aberdeen, Banff, Inverness.

39. H. caledonicum (Hanb.). Caithness and Sutherland.

40. H. Farrense (Hanb.). Sutherland and Shetland Is.

41. H. proximum (Hanb.). Caithness. With regard to all these {362}

Hieracia Sir Joseph Hooker and Mr. Baker say:--"No case can be made of

these. They are local forms with the shadowest of shady characters."

Mr. Bennett writes: "H. iricum and H. Gibsoni are the best marked

forms."

42. \*Campanula rotundifolia (L.), \_var.\_ speciosa (A. G. More). W.

Ireland. "Very well distinguished by its large flowers and small calyx

lobes, approaching the Swiss C. Scheuzeri." (J. D. H.)

43. Statice reticulata (Sm.). "Baker agrees with me that this is also a

Mediterranean species." (J. D. H.)

44. ErythrÃ¦a capitata (Willd.), \_var.\_ sphÃ¦rocephala (Towns.). Isle of

Wight. "A form of \_E. centaurium\_ utterly anomalous in its genus in the

insertion of the stamens. A monster rather than a species." (J. D. H.)

45. \*ErythrÃ¦a latifolia (Sm.). On the sandy dunes near Liverpool. "A

local form." (J. D. H.)

46. Myosotis collina (Hoffim.), \_var.\_ Mittenii (Baker). Sussex.

47. Veronica officinalis (L.), \_var.\_ hirsuta (Hopk.). Ayr, Scotland.

48. Veronica arvensis (L.), \_var.\_ eximia (Towns.). Hampshire.

49. Mentha alopecuroides (Hull). Nearest to \_M. dulcissima\_ (Dum.).

50. Mentha pratensis (Sole). Only once found.

51. Chenopodium rubrum (L.), \_var.\_ pseudobotryoides (H. C. Watson).

52. Salix ferruginea (Forbes). England, Scotland. "Probably a hybrid

between \_S. viminalis\_ and \_S. cinerea\_." (J. D. H.)

53. Salix Grahami (Borr.). Sutherland, Perth. "A hybrid?" (J. D. H.)

54. Salix Sadleri (Syme). Aberdeen. "A hybrid?" (J. D. H.)

55. \*Spiranthes Romanzoviana (Cham.). Ireland (N. America).

56. \*Sisyrinchium angustifolium (Mill.). Ireland. (Arctic and Temp. N.

America.)

57. Allium Babingtonii (Borrer). West England, West Ireland. "A form of

\_A. ampeloprasum\_, itself a naturalised species." (J. D. H.)

58. \*POTAMOGETON LANCEOLATUS (Sm.). Anglesea, Cambridgeshire, Ireland.

Mr. Bennett writes:--"Endemic! I have taken a good amount of trouble to

ascertain this. Nearly 400 specimens I have distributed all over the

world with requests for information as to anything like it. The

response is everywhere the same, 'nothing.' The nearest to it occurs in

the Duchy of Lauenberg but is referable to \_P. heterophyllus\_."

59. Potamogeton Griffithii (Ar. Bennett). Carnarvon. "Nearest to this

is a probable hybrid from N. America, but not identical." (Ar.

Bennett.)

60. Potamogeton pusillus (L.), \_sub-sp.\_ Sturrockii (Ar. Benn.). Perth.

61. Potamogeton pusillus (L.), \_var.\_ rigidus (Ar. Benn.). Orkneys,

Shetlands.

62. Ruppia rostellata (Koch.), \_var.\_ nana (Bosw.). Orkneys.

63. \*Eriocaulon septangulare (With.). Hebrides, Ireland. N. America.

64. Scirpus uniglumis (Link), \_var.\_ Watsoni (Bab.). Scotland, England.

"This is a variety of a sub-species of the common \_S. palustris\_."

(J. D. H.)

65. Luzula pilosa (Willd.), \_var.\_ Borreri (Bromf).

66. \*Carex involuta (Bab.). Cheshire. "A distinct enough plant but

probably a hybrid between \_C. vesicaria\_ and \_C. ampullacea\_, found in

one place only." (J. D. H.)

67. Carex glauca (Murr.), \_var.\_ stictocarpa (Sm.). Scotland.

{363} 68. Carex precox (Jacq.), \_var.\_ capitata (Ar. Benn.). Ireland.

"A remarkable plant (monstrosity?) simulating \_C. capitata\_ (L.)." (Ar.

Bennett.)

69. \*Carex Grahami (Boott). "A mountain form of \_C. vesicaria\_."

(J. D. H.)

70. \*Spartina Townsendi (Groves). Hampshire. "A distinct but very local

form of \_S. stricta\_, found in one place only." (J. D. H.)

71. Agrostis nigra (With.).

72. Deschampsia flexuosa (Trin.), \_var.\_ Voirlichensis (J. C. Melvill).

Perth.

73. \*Deyeuxia neglecta (Kunth), \_var.\_ Hookeri (Syme). Ireland. "A

distinct variety confined to Lough Neagh." (J. D. H.)

74. Glyceria maritima (Willd.), \_var.\_ riparia (Towns.). Hampshire.

75. Poa Balfouri (Bab.). Scotland. "An alpine sub-variety of a variety

of the protean \_P. nemoralis\_." (J. D. H.)

In his comments on this extensive list of supposed peculiar British plants,

Sir Joseph Hooker arrives at the following conclusions:--

1. There are four unquestionably distinct species which do not occur in

continental Europe: viz.--

\_One\_ absolutely endemic species, POTAMOGETON LANCEOLATUS.

\_Three\_ American species, SISYRINCHIUM ANGUSTIFOLIUM, SPIRANTHES

ROMANZOVIANA, ERIOCAULON SEPTANGULARE.

2. There are sixteen endemic varieties of British species, viz.--

\_Eleven\_ of more or less variable species, Caltha palustris, \_var.\_

RADICANS; Polygala vulgaris, \_var.\_ GRANDIFLORA; Cerastium arcticum,

\_var.\_ EDMONSTONII; Trifolium repens, \_var.\_ TOWNSENDII; Rosa involuta,

\_var.\_ WILSONI; Rubus fruticosus, \_sub-sp.\_ LONGITHYRSIGER; Campanula

rotundifolia, \_var.\_ SPECIOSA; ErythrÃ¦a centaurium, \_sub-sp.\_

LATIFOLIA; Carex involuta, (? Hyb.); Carex vesicaria, \_var.\_ GRAHAMI;

Deyeuxia neglecta, \_var.\_ HOOKERI.

\_Five\_ of comparatively well limited species. Arabis petrÃ¦a, \_var.\_

GRANDIFOLIA; Helianthemum guttatum, \_var.\_ BREWERI; Geranium

sanguineum, \_var.\_ LANCASTRIENSE; Oenanthe Phellandrium, \_var.\_

FLUVIATILIS; Spartium stricta, \_var.\_ TOWNSENDI.

The above twenty species are marked in the list with an asterisk. Of the

remaining fifty-five, Sir Joseph Hooker says, "that for various reasons it

would not be safe to rely on them as evidence. In most cases the varietal

form is so very trifling a departure from the type that this may be safely

set down to a local cause, and is probably not constant. In others the

plant is doubtfully endemic; in still others a hybrid."

Even should it ultimately prove that of the whole number of the fifty-five

doubtful forms none are established as peculiar British varieties, the

number admitted after so {364} rigorous an examination is about what we

should expect in comparison with the limited amount of speciality we have

seen to exist in other groups. The three American species which inhabit the

extreme west and north-west of the British Isles, but are not found on the

continent of Europe are especially interesting, because they demonstrate

the existence of some peculiar conditions such as would help to explain the

presence of the other peculiar species. Whether we suppose these American

forms to have migrated from America to Europe before the glacial epoch, or

to be the remnants of a vegetation once spread over the north temperate

zone, we can only explain their presence with us and not further east by

something favourable either in our insular climate or in the limited

competition due to our comparative poverty in species.

About half of the peculiar forms are found in the extreme west or north of

Britain or in Ireland, where peculiar insular conditions are at a maximum;

and the influence of these conditions is further shown by the number of

species of West or South European plants which occur in the same districts.

We may here notice the interesting fact that Ireland possesses no less than

twenty species or sub-species of flowering plants not found in Britain, and

some of these \_may\_ be altogether peculiar. As a whole they show the effect

of the pre-eminently mild and insular climate of Ireland in extending the

range of some south European species. The following list of these plants,

for which I am indebted to Mr. A. G. More, with a few remarks on their

distribution, will be found interesting:--

LIST OF IRISH FLOWERING PLANTS WHICH ARE NOT FOUND IN BRITAIN.

1. \_Polygala vulgaris\_ (\_var.\_ grandiflora). Sligo.

2. \_Campanula rotundifolia\_ (\_var.\_ speciosa). W. Ireland.

3. \_Arenaria ciliata.\_ W. Ireland (also Auvergne, Pyrenees, Crete).

4. \_Saxifraga umbrosa.\_ W. Ireland (also Pyrenees, N. Spain, Portugal).

5. ,, \_geum.\_ S. W. Ireland (also Pyrenees).

6. ,, \_hirsuta.\_ S. W. Ireland (also Pyrenees).

7. \_Inula salicina.\_ W. Ireland (Scandinavia, Middle and South Europe).

8. \_Erica mediterranea.\_ W. Ireland (W. France, Spain, Portugal).

9. ,, \_mackaiana\_ (\_tetralix\_ sub.-sp.) W. Ireland (Spain).

10. \_Arbutus unedo.\_ S. W. Ireland (W. of France, Spain, Portugal and

shores of Mediterranean).

11. \_Dabeocia polifolia.\_ W. Ireland (W. of France, Spain and

Portugal).

{365} 12. \_Pinguicula grandiflora.\_ S. W. Ireland (Spain, Pyrenees,

Alps of France and Switzerland).

13. \_Neotinea intacta.\_ W. Ireland (S. France, Portugal, Spain, and

shores of Mediterranean).

14. \_Spiranthes romanzoviana.\_ S. W. Ireland (North America).

15. \_Sisyrinchium angustifolium.\_ W. Ireland (North America, Arctic and

Temp.).

16. \_Potamogeton lonchites.\_ Ireland, Mr. Arthur Bennett informs me

that this is certainly not British or European, but may possibly be

identical with \_P. fluitans\_ \_var.\_ \_Americanus\_ of the U. States.

17. \_Potamogeton kirkii\_ (\_natans\_ sub.-sp.). W. Ireland. (Arctic

Europe?)

18. \_Eriocaulon septangulare.\_ W. Ireland, Skye, Hebrides (North

America).

19. \_Carex buxbaumii.\_ N. E. Ireland, on an island in Lough Neagh

(Arctic and Alpine Europe, North America).

20. \_Deyeuxia neglecta\_ (\_var.\_ \_Hookeri\_). On the shores and islands

of Lough Neagh. (And in Germany, Arctic Europe, and North America.)

We find here nine south-west European species which probably had a wider

range in mild preglacial times, and have been preserved in the south and

west of Ireland owing to its milder climate. It must be remembered that

during the height of the glacial epoch Ireland was continental, so that

these plants may have followed the retreating ice to their present stations

and survived the subsequent depression. This seems more probable than that

so many species should have reached Ireland for the first time during the

last union with the continent subsequent to the glacial epoch. The Arctic,

Alpine, and American plants may all be examples of species which once had a

wider range, and which, owing to the more favourable conditions, have

continued to exist in Ireland while becoming extinct in the adjacent parts

of Britain and Western Europe.

As contrasted with the extreme scarcity of peculiar species among the

flowering plants, it is the more interesting and unexpected to find a

considerable number of peculiar mosses and HepaticÃ¦, some of which present

us with phenomena of distribution of a very remarkable character. For the

following lists and the information as to the distribution of the genera

and species I am indebted to Mr. William Mitten, one of the first

authorities on these beautiful little plants. That of the mosses has been

corrected for this edition by Dr. R. Braithwaite, and several species of

hepaticÃ¦ have been added by Mr. Mitten. {366}

LIST OF THE SPECIES OF MOSSES AND HEPATICÃ WHICH ARE PECULIAR TO THE

BRITISH ISLES (OR NOT FOUND IN EUROPE).

(\_Those belonging to non-European genera in Italics.\_)

MOSSES.

1. Systegium Mittenii South England.

2. Campylopus Shawii North Britain.

3. ,, setifolius Ireland, Wales, and Hebrides.

4. Seligeria calcicola South England.

5. Pottia viridifolia South England.

6. Leptodontium recurvifolium Ireland and Scotland.

7. Tortula Hybernica Ireland.

8. \_Streptopogon gemmascens\_ Sussex.

9. Bryum barbatum Scotland.

10. \_Bartramidula Wilsoni\_ Ireland, Wales, and Scotland.

11. \_Daltonia splachnoides\_ Ireland, Antilles, and Mexico.

12. \_Hookeria laetevirens\_ Ireland, Cornwall, and Madeira.

13. Hypnum micans Ireland.

14. Myurium Hebridarium Hebrides and Atlantic Islands.

15. Hedwigia ciliata \_var.\_ striata Wales and Scotland.

HEPATICÃ.

1. Frullania germana Ireland.

2. ,, HutchinsiÃ¦ Ireland, Scotland, Wales, Devon,

Tropical regions.

3. Lejeunia flava Ireland, Atlantic Islands, S. America,

Africa, &c.

4. ,, microscopica Ireland, Wales, Cumberland, Madeira.

5. ,, Holtii Ireland (Killarney).

6. ,, diversiloba Ireland (Killarney), Mexico?

7. ,, patens Ireland.

8. Radula tenax Ireland.

9. ,, Holtii Ireland.

10. ,, voluta Ireland, Wales, Cumberland, Mexico?

11. ,, Carringtonii Ireland.

12. Lepidozia Pearsoni Wales.

13. Adilocolia decipiens Ireland, Wales, Africa, and S. America.

14. Cephalozia aeraria Wales.

15. Lophocolia spicata Ireland, Cornwall, Anglesea.

16. Martinellia nimbosa Ireland (Brandon Mountain).

17. Plagiochila spinulosa Wales, Ireland, and Scotland, Atlantic

Islands.

18. ,, ambagiosa Ireland, India.

19. Jamesoniella Carringtonii Scotland.

20. Gymnocolea Nevicensis Scotland.

21. Jungermannia Doniana Scotland.

22. Cesia crenulata Ireland, Wales.

23. Chasmatocolea cuneifolia Ireland.

24. Aerobolbus Wilsoni Ireland, S. America, New Zealand.

25. Petalophyllum Ralfsii Ireland, Cornwall, Devon.

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Many of the above are minute or obscure plants, and are closely allied to

other European species with which they may have been confounded. We cannot

therefore lay any stress on these individually as being absent from the

continent of Europe so much of which is imperfectly explored, though it is

probable that several of them are really confined to Britain. But there are

a few--indicated by italics--which are in a very different category; for

they belong to genera which are altogether unknown in any other part of

Europe, and their nearest allies are to be found in the tropics or in the

southern hemisphere. The four non-European genera of mosses to which we

refer all have their maximum of development in the Andes, while the three

non-European HepaticÃ¦ appear to have their maximum in the temperate regions

of the southern hemisphere. Mr. Mitten has kindly furnished me with the

following particulars of the distribution of these genera:--

BARTRAMIDULA. Asia, Africa, S. America and Australia, but not Europe or

N. America.

STREPTOPOGON is a comparatively small genus, with seven species in the

Andes, one in the Himalayas, and three in the south temperate zone,

besides our English species.

DALTONIA is a large genus of inconspicuous mosses, having seventeen

species in the Andes, two in Brazil, two in Mexico, one in the

Galapagos, six in India and Ceylon, five in Java, two in Africa, and

three in the Antarctic Islands, and one in Ireland.

HOOKERIA (restricting that term to the species referable to

Cyclodictyon) is still a large genus of handsome and remarkable mosses,

having twenty-six species in the Andes, eleven in Brazil, eight in the

Antilles, one in Mexico, two in the Pacific Islands, one in New

Zealand, one in Java, one in India, and five in Africa--besides our

British species, which is found also in Madeira and the Azores but in

no part of Europe proper.

These last two are very remarkable cases of distribution, since Mr. Mitten

assures me that the plants are so markedly different from all other mosses

that they would scarcely be overlooked in Europe.

The distribution of the non-European genera of HepaticÃ¦ is as follows:--

CHASMATOCOLIA. South America and Ireland.

ACROBOLBUS. A small genus found only in New Zealand and the adjacent

islands, besides Ireland.

{368} PETALOPHYLLUM. A small genus confined to Australia and New

Zealand in the southern hemisphere, Algeria, and Ireland in the

northern. We have also one of the HepaticÃ¦--\_Mastigophora

Woodsii\_--found in Ireland and the Himalayas, but unknown in any part

of continental Europe. The genus is most developed in New Zealand.

These are certainly very interesting facts, but they are by no means so

exceptional in this group of plants as to throw any doubt upon their

accuracy. The Atlantic islands present very similar phenomena in the

\_Rhamphidium purpuratum\_, whose nearest allies are in the West Indies and

South America; and in three species of Sciaromium, whose only allies are in

New Zealand, Tasmania, and the Andes of Bogota. An analogous and equally

curious fact is the occurrence in the Drontheim mountains in Central

Norway, of a little group of four or five peculiar species of mosses of the

genus Mnium, which are found nowhere else; although the genus extends over

Europe, India, and the southern hemisphere, but always represented by a

very few wide-ranging species except in this one mountain group![85]

Such facts show us the wonderful delicacy of the balance of conditions

which determine the existence of particular species in any locality. The

spores of mosses and HepaticÃ¦ are so minute that they must be continually

carried through the air to great distances, and we can hardly doubt that,

so far as its powers of diffusion are concerned, any species which fruits

freely might soon spread itself over the whole world. That they do not do

so must depend on peculiarities of habit and constitution, which fit the

different species for restricted stations and special climatic conditions;

and according as the adaptation is more general, or the degree of

specialisation extreme, species will have wide or restricted ranges.

Although their fossil remains have been rarely detected, we can hardly

doubt that mosses have as high an antiquity as ferns or Lycopods; and

coupling this antiquity with their great powers of dispersal we may

understand how many of the genera have come to occupy a number of detached

areas scattered over the whole earth, but {369} always such as afford the

peculiar conditions of climate and soil best suited to them. The repeated

changes of temperature and other climatic conditions, which, as we have

seen, occurred through all the later geological epochs, combined with those

slower changes caused by geographical mutations, must have greatly affected

the distribution of such ubiquitous yet delicately organised plants as

mosses. Throughout countless ages they must have been in a constant state

of comparatively rapid migration, driven to and fro by every physical and

organic change, often subject to modification of structure or habit, but

always seizing upon every available spot in which they could even

temporarily maintain themselves.[86]

Here then we have a group in which there is no question of the means of

dispersal; and where the difficulties that present themselves are not how

the species reached the remote localities in which they are now found, but

rather why they have not established themselves in {370} many other

stations which, so far as we can judge, seem equally suitable to them. Yet

it is a curious fact, that the phenomena of distribution actually presented

by this group do not essentially differ from those presented by the higher

flowering plants which have apparently far less diffusive power, as we

shall find when we come to treat of the floras of oceanic islands; and we

believe that the explanation of this is, that the life of \_species\_, and

especially of \_genera\_, is often so prolonged as to extend over whole

cycles of such terrestrial mutations as we have just referred to; and that

thus the majority of plants are afforded means of dispersal which are

usually sufficient to carry them into all suitable localities on the globe.

Hence it follows that their actual existence in such localities depends

mainly upon vigour of constitution and adaptation to conditions just as it

does in the case of the lower and more rapidly diffused groups, and only

partially on superior facilities for diffusion. This important principle

will be used further on to afford a solution of some of the most difficult

problems in the distribution of plant life.[87]

\_Concluding Remarks on the Peculiarities of the British Fauna and

Flora.\_--The facts, now I believe for the first time brought together,

respecting the peculiarities of the British fauna and flora, are sufficient

to show that there is considerable scope for the study of geographical

distribution even in so apparently unpromising a field as one of the most

recent of continental islands. Looking at the general bearing of these

facts, they prove, that the idea so generally entertained as to the

biological identity of the British Isles with the adjacent continent is not

altogether correct. Among birds we have undoubted peculiarities in at least

three instances; peculiar fishes are much more numerous, and in this case

the fact that the Irish species {371} are almost all different from the

British, and those of the Orkneys distinct from those of Scotland, renders

it almost certain that the great majority of the fifteen peculiar British

fishes are really peculiar and will never be found on the European

Continent. The mosses and HepaticÃ¦ also have been sufficiently collected in

Europe to render it pretty certain that the more remarkable of the peculiar

British forms are not found there; why therefore, it may be well asked,

should there not be a proportionate number of peculiar British insects? It

is true that numerous species have been first discovered in Britain, and,

subsequently, on the continent; but we have many species which have been

known for twenty, thirty, or forty years, some of which are not rare with

us, and yet have never been found on the continent. We have also the

curious fact of our outlying islands, such as the Shetland Isles, the Isle

of Man, and the little Lundy Island, possessing each some peculiar forms

which, \_certainly\_, do not exist on our principal island which has been so

very thoroughly worked. Analogy, therefore, would lead us to conclude that

many other species or varieties would exist on our islands and not on the

continent; and when we find that a very large number (150) in three orders

only, are so recorded, we may I think be sure that some considerable

portion of these (though how many we cannot say) are really endemic British

species.

The general laws of distribution also lead us to expect such phenomena.

Very rare and very local species are such as are becoming extinct; and it

is among insects, which are so excessively varied and abundant, which

present so many isolated forms, and which, even on continents, afford

numerous examples of very rare species confined to restricted areas, that

we should have the best chance of meeting with every degree of rarity down

to the point of almost complete extinction. But we know that in all parts

of the world islands are the refuge of species or groups which have become

extinct elsewhere; and it is therefore in the highest degree probable that

some species which have ceased to exist on the continent should be

preserved in some part or other of our islands, especially {372} as these

present favourable climatic conditions such as do not exist elsewhere.

There is therefore a considerable amount of harmony in the various facts

adduced in this chapter, as well as a complete accordance with what the

laws of distribution in islands would lead us to expect. In proportion to

the species of birds and fresh-water fishes, the number of insect-forms is

enormously great, so that the numerous species or varieties here recorded

as not yet known on the continent are not to be wondered at; while it

would, I think, be almost an anomaly if, with peculiar birds and fishes

there were \_not\_ a fair proportion of peculiar insects. Our entomologists

should, therefore, give up the assumption, that all our insects do exist on

the continent, and will some time or other be found there, as not in

accordance either with the evidence or the probabilities of the case; and

when this is done, and the interesting peculiarities of some of our smaller

islands are remembered, the study of our native animals and plants, in

relation to those of other countries, will acquire a new interest. The

British Isles are said to consist of more than a thousand islands and

islets. How many of these have ever been searched for insects? With the

case of Lundy Island before us, who shall say that there is not yet scope

for extensive and interesting investigations into the British fauna and

flora?

\* \* \* \* \*

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CHAPTER XVII

BORNEO AND JAVA

Position and Physical Features of Borneo--Zoological Features of

Borneo: Mammalia--Birds--The Affinities of the Bornean Fauna--Java, its

Position and Physical Features--General Character of the Fauna of

Java--Differences Between the Fauna of Java and that of the other Malay

Islands--Special Relations of the Javan Fauna to that of the Asiatic

Continent--Past Geographical Changes of Java and Borneo--The Philippine

Islands--Concluding Remarks on the Malay Islands.

As a representative of recent continental islands situated in the tropics,

we will take Borneo, since, although perhaps not much more ancient than

Great Britain, it presents a considerable amount of speciality; and, in its

relations to the surrounding islands and the Asiatic continent, offers us

some problems of great interest and considerable difficulty.

The accompanying map shows that Borneo is situated on the eastern side of a

submarine bank of enormous extent, being about 1,200 miles from north to

south, and 1,500 from east to west, and embracing Java, Sumatra, and the

Malay Peninsula. This vast area is all included within the 100 fathom line,

but by far the larger part of it--from the Gulf of Siam to the Java Sea--is

under fifty fathoms, or about the same depth as the sea that separates our

own island from the continent. The distance from Borneo to the southern

extremity of the Malay Peninsula is about 350 miles, and it is nearly as

far from Sumatra and Java, while it is more than 600 miles from the Siamese

Peninsula, opposite to which its long northern coast extends. There is, I

believe, nowhere else upon the globe, an island so far from a continent,

yet separated from it by so shallow a sea. Recent changes of sea and land

must have occurred here on a grand scale, and this adds to the interest

attaching to the study of this large island.

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[Illustration: MAP OF BORNEO AND JAVA, SHOWING THE GREAT SUBMARINE BANK OF

SOUTH-EASTERN ASIA.]

The light tint shows a less depth than 100 fathoms.

The figures show the depth of the sea in fathoms.

{375} The internal geography of Borneo is somewhat peculiar. A large

portion of its surface is lowland, consisting of great alluvial valleys

which penetrate far into the interior; while the mountains except in the

north, are of no great elevation, and there are no extensive plateaux. A

subsidence of 500 feet would allow the sea to fill the great valleys of the

Pontianak, Banjarmassing, and Coti rivers, almost to the centre of the

island, greatly reducing its extent, and causing it to resemble in form the

island of Celebes to the east of it.

In geological structure Borneo is thoroughly continental, possessing

formations of all ages, with basalt and crystalline rocks, but no recent

volcanoes. It possesses vast beds of coal of Tertiary age; and these, no

less than the great extent of alluvial deposits in its valleys, indicate

great changes of level in recent geological times.

Having thus briefly indicated those physical features of Borneo which are

necessary for our inquiry, let us turn to the organic world.

Neither as regards this great island nor those which surround it, have we

the amount of detailed information in a convenient form that is required

for a full elucidation of its past history. We have, however, a tolerable

acquaintance with the two higher groups--mammalia and birds, both of Borneo

and of all the surrounding countries, and to these alone will it be

necessary to refer in any detail. The most convenient course, and that

which will make the subject easiest for the reader, will be to give, first,

a connected sketch of what is known of the zoology of Borneo itself, with

the main conclusions to which they point; and then to discuss the mutual

relations of some of {376} the adjacent islands, and the series of

geographical changes that seem required to explain them.

ZOOLOGICAL FEATURES OF BORNEO.

\_Mammalia.\_--Nearly a hundred and forty species of mammalia have been

discovered in Borneo, and of these more than three-fourths are identical

with those of the surrounding countries, and more than one half with those

of the continent. Among these are two lemurs, nine civets, five cats, five

deer, the tapir, the elephant, the rhinoceros, and many squirrels, an

assemblage which could certainly only have reached the country by land. The

following species of mammalia are supposed to be peculiar to Borneo:--

QUADRUMANA.

1. Simia morio. A small orangutan

with large incisor teeth.

2. Hylobates mulleri.

3. Nasalis larvatus.

4. Semnopithecus rubicundus.

5. " chrysomelas.

6. " frontatus.

7. " hosei. (Thomas.) Kini Balu.

CARNIVORA.

8. Herpestes semitorquatus.

9. Felis badia.

UNGULATA.

10. Sus barbatus.

RODENTIA.

11. Pteromys phÃ¦omelas.

12. Sciurus jentinki. (Th.) Kini Balu.

13. Sciurus whiteheadi. (Th.) Kini Balu.

14. " everetti.

15. Rheithrosciurus macrotis.

16. Hystrix crassispinis.

17. Trichys guentheri.

18. Mus infraluteus. (Th.) Kini Balu.

19. " alticola. (Th.) Kini Balu.

INSECTIVORA.

20. Tupaia splendidula.

21. " minor.

22. " dorsalis.

23. Dendrogale murina.

CHIROPTERA.

24. Vesperugo stenopterus.

25. " doriÃ¦

26. Cynopterus brachyotus.

27. " lucasii.

28. " spadiceus.

29. Hipposideros doriÃ¦.

Of the twenty-nine peculiar species here enumerated it is possible that a

few may be found to be identical with those of Malacca or Sumatra; but

there are also four peculiar genera which are less likely to be discovered

elsewhere. These are Nasalis, the remarkable long-nosed monkey;

Rheithrosciurus, a peculiar form of squirrel; and Trichys, a tailless

porcupine. These peculiar forms do not, however, imply that the separation

of the island from the continent is of very ancient date, for the country

is so vast and {377} so much of the once connecting land is covered with

water, that the amount of speciality is hardly, if at all, greater than

occurs in many continental areas of equal extent and remoteness. This will

be more evident if we consider that Borneo is as large as the Indo-Chinese

Peninsula, or as the Indian Peninsula south of Bombay, and if either of

these countries were separated from the continent by the submergence of the

whole area north of them as far as the Himalayas, they would be found to

contain quite as many peculiar genera and species as Borneo actually does

now. A more decisive test of the lapse of time since the separation took

place is to be found in the presence of a number of representative species

closely allied to those of the surrounding countries, such as the tailed

monkeys and the numerous squirrels. These relationships, however, are best

seen among the birds, which have been more thoroughly collected and more

carefully studied than the mammalia.

\_Birds.\_--About 580 species of birds are now known to inhabit Borneo, of

which 420 species are land-birds.[88] One hundred and eight species are

supposed to be peculiar to the island, and of these one half have been

noted, either by Count Salvadori or Mr. Everett, as being either

representative species of, or closely allied to birds inhabiting other

islands or countries. The majority of these are, as might be expected,

allied to species inhabiting the surrounding countries, especially Sumatra,

the Malay Peninsula, or Java, a smaller number having their representative

forms in the Philippine Islands or Celebes. But there is another group of

eight species whose nearest allies are found in such remote lands as

Ceylon, North India, Burma, or China. These last have been indicated in the

following list by a double star (\*\*) while those which are representative

of forms found in the immediately surrounding area, and are in many cases

very slightly differentiated from their allies, are indicated by a single

star (\*). {378}

LIST OF BIRDS WHICH ARE SUPPOSED TO BE PECULIAR TO BORNEO.

TURDIDÃ (Thrushes).

1. \*\*Cettia oreophila.

2. \*Merula seebohmi.

3. \*\*Geocichla aurata.

4. \*\*Myiophoneus borneensis.

5. Brachypteryx erythrogyna.

6. Copsychus niger.

7. \*Cittocincla suavis.

8. \* ,, stricklandi.

9. \*Henicurus borneensis.

10. \*Phyllergates cinereicollis.

11. Burnesia superciliaris.

TIMELIIDÃ (Babbling Thrushes).

12. \*Garrulax schistochlamys.

13. Rhinocichla treacheri.

14. Allocotops calvus.

15. \*\*Stachyris borneensis.

16. Cyanoderma bicolor.

17. Chlorocharis Ã¦miliÃ¦.

18. Androphilus accentor.

19. Malacopterum cinereocapillum.

20. \*\*Staphidia everetti.

21. \*Herporius brunnescens.

22. \*Mixornis borneensis.

23. \* ,, montana.

24. \*Turdinus canicapillus.

25. ,, atrigularis.

26. \*Drymocataphus capistratoides.

27. Ptilophaga rufiventris.

28. ,, leucogrammica.

29. \*Corythocichla crassa.

30. \*Turdinulus exsul.

31. Orinthocichla whiteheadi.

BRACHYPODIDÃ (Bulbuls).

32. \*Hemixus connectens.

33. Criniger diardi.

34. \* ,, ruficrissus.

35. Tricophoropsis typus.

36. Oreostictes leucops.

37. Rubigula montis.

38. \* ,, paroticalis.

39. Chloropsis kinabaluensis.

40. \* ,, irridinucha.

ORIOLIDÃ (Orioles).

41. Oriolus consobrinus.

42. \*Oriolus vulneratus.

PARIDÃ (Tits).

43. Parus sarawakensis.

44. \*Dendrophila corallipes.

LANIIDÃ (Shrikes).

45. Pityriasis gymnocephala.

46. \*Hyloterpe hypoxantha.

DICRURIDÃ (Drongo-shrikes).

47. \*Chibia borneensis.

CAMPOPHAGIDÃ (Caterpillar-catchers).

48. ChlamodychÃ¦ra jeffreyi.

49. \*Artamides normani.

50. Pericrocotus cinereigula.

MUSCICAPIDÃ (Flycatchers).

51. \*\*Hemichelidon cinereiceps.

52. \*Rhinomyias gularis.

53. \* ,, ruficrissa.

54. Cryptolopha schwaneri.

55. ,, montis.

56. \*Stoparola cerviniventris.

57. Siphia coeruleata.

58. ,, beccariana.

59. ,, clopurensis.

60. ,, obscura.

61. ,, everetti.

62. ,, nigrogularis.

NECTARINEIDÃ (Sun-birds).

63. Arachnothera juliÃ¦.

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DICÃIDÃ (Flower-peckers).

64. \*Diceum monticolum.

65. \* ,, pryeri.

66. \*Prionochilus xanthopygius.

67. \*\*Prionochilus everetti.

68. \*Zosterops clara.

PLOCEIDÃ (Weavers).

69. Chlorura borneensis.

70. Munia fuscans.

CORVIDÃ (Crows).

71. \*Dendrocitta cinerascens.

72. Cissa jeffreyi.

73. \*Platysmurus aterrimus.

PITTIDÃ (Ground Thrushes).

74. Pitta bertÃ¦.

75. ,, arcuata.

76. ,, baudi.

77. \*Pitta usheri.

78. \* ,, granatina.

79. \* ,, schwaneri.

EURYLÃMIDÃ (Gapers).

80. Calyptomena whiteheadi.

CYPSELIDÃ (Swifts).

81. Cypselus lowi.

PODARGIDÃ (Frogmouths).

82. \*Batrachostomus adspersus.

CAPRIMULGIDAE (Goatsuckers).

83. Caprimulgus borneensis.

84. Caprimulgus concretus.

PICIDÃ (Woodpeckers).

85. \*Jyngipicus aurantiiventris.

86. ,, picatus.

87. \*Micropternus badiosus.

88. Sasia everetti.

ALCEDINIDÃ (Kingfishers).

89. \*Pelargopsis leucocephala.

90. \*Carcineutes melanops.

TROGONIDÃ (Trogons).

91. Harpactes whiteheadi.

CUCULIDÃ (Cuckoos).

92. \*Rhopodytes borneensis.

CAPITONIDÃ (Barbets).

93. Cyanops pulcherrimus.

94. ,, monticulus.

95. \*MegalÃ¦ma chrysopsis.

BUBONIDÃ (Owls).

96. Heteroscops luciÃ¦.

97. \*Syrnium leptogrammicum.

FALCONIDÃ (Hawks, &c.).

98. Spilornis pallidus.

99. \*Accipiter nigrotibialis.

100. Microhierax latifrons.

PHASIANIDÃ (Pheasants).

101. Polyplectron schliermacheri.

102. Lobiophasis bulweri.

103. \*Argusianus grayi.

104. \*Euplocamus pyrronotus.

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TETRAONIDÃ (Grouse, &c.).

105. Bambusicola hyperythra.

106. ,, erythrophrys.

107. HÃ¦matortyx sanguiniceps.

RALLIDÃ (Rails).

108. Rallina rufigenys.

Representative forms of the same character as those noted above are found

in all extensive continental areas, but they are rarely so numerous. Thus,

in Mr. Elwes' paper on the "Distribution of Asiatic Birds," he states that

12.5 per cent. of the land birds of Burmah and Tenasserim are peculiar

species, whereas we find that in Borneo they are about 25 per cent., and

the difference may fairly be imputed to the greater proportion of slightly

modified representative species due to a period of complete isolation. Of

peculiar genera, the Indo-Chinese Peninsula has one--Ampeliceps, a

remarkable yellow-crowned starling, with bare pink-coloured orbits; while

two others, Temnurus and Crypsirhina--singular birds allied to the

jays--are found in no other part of the Asiatic continent though they occur

in some of the Malay Islands. Borneo has seven peculiar genera of

passeres,[89] as well as HÃ¦matortyx, a crested partridge; and Lobiophasis,

a pheasant hardly distinct from Euplocamus; while two others, Pityriasis,

an extraordinary bare-headed bird between a jay and a shrike, and

Carpococcyx, a pheasant-like ground cuckoo formerly thought to be peculiar,

are said to have been discovered also in Sumatra.

The insects and land-shells of Borneo and of the surrounding countries are

too imperfectly known to enable us to arrive at any accurate results with

regard to their distribution. They agree, however, with the birds and

mammals in their general approximation to Malayan forms, but the number of

peculiar species is perhaps larger.

The proportion here shown of less than one-fourth peculiar species of

mammalia and fully one-fourth peculiar species of land-birds, teaches us

that the possession of the power of flight affects but little the

distribution of {381} land-animals, and gives us confidence in the results

we may arrive at in those cases where we have, from whatever cause, to

depend on a knowledge of the birds alone. And if we consider the wide range

of certain groups of powerful flight--as the birds of prey, the swallows

and swifts, the king-crows, and some others, we shall be forced to conclude

that the majority of forest-birds are restricted by even narrow watery

barriers, to an even greater extent than mammalia.

\_The Affinities of the Bornean Fauna.\_--The animals of Borneo exhibit an

almost perfect identity in general character, and a close similarity in

species, with those of Sumatra and the Malay Peninsula. So great is this

resemblance that it is a question whether it might not be quite as great

were the whole united; for the extreme points of Borneo and Sumatra are

1,500 miles apart--as far as from Madrid to Constantinople, or from the

Missouri valley to California. In such an extent of country we always meet

with some local species, and representative forms, so that we hardly

require any great lapse of time as an element in the production of the

peculiarities we actually find. So far as the forms of life are concerned,

Borneo, as an island, may be no older than Great Britain; for the time that

has elapsed since the glacial epoch would be amply sufficient to produce

such a redistribution of the species, consequent on their mutual relations

being disturbed, as would bring the islands into their present zoological

condition. There are, however, other facts to be considered, which seem to

imply much greater and more complex revolutions than the recent separation

of Borneo from Sumatra and the Malay Peninsula, and that these changes must

have been spread over a considerable lapse of time. In order to understand

what these changes probably were, we must give a brief sketch of the fauna

of Java, the peculiarities of which introduce a new element into the

question we have to discuss. {382}

JAVA.

The rich and beautiful island of Java, interesting alike to the politician,

the geographer, and the naturalist, is more especially attractive to the

student of geographical distribution, because it furnishes him with some of

the most curious anomalies and difficult problems in a place where such

would be least expected. As Java forms with Sumatra one almost unbroken

line of volcanoes and volcanic mountains, interrupted only by the narrow

Straits of Sunda, we should naturally expect a close resemblance between

the productions of the two islands. But in point of fact there is a much

greater difference between them than between Sumatra and Borneo, so much

further apart, and so very unlike in physical features.[90] Java differs

from the three great land masses--Borneo, Sumatra, and the Malay Peninsula,

far more than either of these do from each other; and this is the first

anomaly we encounter. But a more serious difficulty than this remains to be

stated. Java has certain close resemblances to the Siamese Peninsula, and

also to the Himalayas, which Borneo and Sumatra do not exhibit to so great

a proportionate extent; and looking at the relative position of these lands

respectively, this seems most incomprehensible. In order fully to

appreciate the singularity and difficulty of the problem, it will be

necessary to point out the exact nature and amount of these peculiarities

in the fauna of Java.

\_General Character of the Fauna of Java.\_--If we were only to take account

of the number of peculiar species in Java, and the relations of its fauna

generally to that of the surrounding lands, we might pass it over as a less

interesting island than Borneo or Sumatra. Its mammalia (ninety species)

are nearly as numerous as those of Borneo, but are apparently less

peculiar, none of the genera and only five or six of the species being

confined to the island. In land-birds it is decidedly less rich, having

only 300 species, of which about forty-five are peculiar, and only one

{383} or two belong to peculiar genera; so that here again the amount of

speciality is considerably less than in Borneo. It is only when we proceed

to analyse the species of the Javan fauna, and trace their distribution and

affinities, that we discover its interesting nature.

\_Difference Between the Fauna of Java and that of the other great Malay

Islands.\_--Comparing the fauna of Java with that which may be called the

typical Malayan fauna as exhibited in Borneo, Sumatra, and the Malay

Peninsula, we find the following differences. No less than thirteen genera

of mammalia, each of which is known to inhabit at least two, and generally

all three, of the above-named Malayan countries, are totally absent from

Java; and they include such important forms as the elephant, the tapir, and

the Malay bear. It cannot be said that this difference depends on imperfect

knowledge, for Java is one of the oldest European settlements in the East,

and has been explored by a long succession of Dutch and English

naturalists. Every part of it is thoroughly well known, and it would be

almost as difficult to find a new mammal of any size in Europe as in Java.

Of birds there are twenty-five genera, all typically Malayan and occurring

at least in two, and for the most part in all three of the Malay countries,

which are yet absent from Java. Most of these are large and conspicuous

forms, such as jays, gapers, bee-eaters, woodpeckers, hornbills, cuckoos,

parrots, pheasants, and partridges, as impossible to have remained

undiscovered in Java as the large mammalia above referred to.

Besides these absent \_genera\_ there are some curious illustrations of Javan

isolation in the \_species\_; there being several cases in which the same

species occurs in all three of the typical Malay countries, while in Java

it is represented by an allied species. These occur chiefly among birds,

there being no less than seven species which are common to the three great

Malay countries but are represented in Java by distinct though closely

allied species.

From these facts it is impossible to doubt that Java has had a history of

its own, quite distinct from that of the other portions of the Malayan

area. {384}

\_Special Relations of the Javan Fauna to that of the Asiatic

Continent.\_--These relations are indicated by comparatively few examples,

but they are very clear and of great importance. Among mammalia, the genus

Helictis is found in Java but in no other Malay country, though it inhabits

also North India; while two species, \_Rhinoceros javanicus\_ and \_Lepus

kurgosa\_, are natives of Indo-Chinese countries and Java, but not of

typical Malaya. In birds there are five genera or sub-genera--Zoothera,

Notodela, Crypsirhina, Allotrius, and Cochoa, which inhabit Java, the

Himalayas, and Indo-China, all but the last extending south to Tenasserim,

but none of them occurring in Malacca, Sumatra, or Borneo. There are also

two species of birds--a trogon (\_Harpactes oreskios\_), and the Javanese

peacock (\_Pavo muticus\_), which inhabit only Java and the Indo-Chinese

countries, the former reaching Tenasserim and the latter Perak in the Malay

Peninsula.

Here, then, we find a series of remarkable similarities between Java and

the Asiatic continent, quite independent of the typical Malay

countries--Borneo, Sumatra, and the Malay Peninsula, which latter have

evidently formed one connected land, and thus appear to preclude any

independent union of Java and Siam.

The great difficulty in explaining these facts is, that all the required

changes of sea and land must have occurred within the period of existing

species of mammalia. Sumatra, Borneo, and Malacca have, as we have seen, a

great similarity as regards their species of mammals and birds, while Java,

though it differs from them in so curious a manner, has no greater degree

of speciality, since its species, when not Malayan, are almost all North

Indian or Siamese.

There is, however, one consideration which may help us over this

difficulty. It seems highly probable that in the equatorial regions species

have changed less rapidly than in the north temperate zone, on account of

the equality and stability of the equatorial climate. We have seen, in

Chapter X., how important an agent in producing extinction and modification

of species must have been the repeated changes from cold to warm, and from

warm to cold {385} conditions, with the migrations and crowding together

that must have been their necessary consequence. But in the lowlands, near

the equator, these changes would be very little if at all felt, and thus

one great cause of specific modification would be wanting. Let us now see

whether we can sketch out a series of not improbable changes which may have

brought about the existing relations of Java and Borneo to the continent.

\_Past Geographical Changes of Java and Borneo.\_--Although Java and Sumatra

are mainly volcanic, they are by no means wholly so. Sumatra possesses in

its great mountain masses ancient crystalline rocks with much granite,

while there are extensive Tertiary deposits of Eocene age, overlying which

are numerous beds of coal now raised up many thousand feet above the

sea.[91] The volcanoes appear to have burst through these older mountains,

and to have partly covered them as well as great areas of the lowlands with

the products of their eruptions. In Java either the fundamental strata were

less extensive and less raised above the sea, or the period of volcanic

action has been of longer duration; for here no crystalline rocks have been

found except a few boulders of granite in the western part of the island,

perhaps the relics of a formation destroyed by denudation or covered up by

volcanic deposits. In the southern part of Java, however, there is an

extensive range of low mountains, about 3,000 feet high, consisting of

basalt with limestone, apparently of Miocene age.

During this last named period, then, Java would have been at least 3,000

feet lower than it is now, and such a depression would probably extend to

considerable parts of Sumatra and Borneo, so as to reduce them all to a few

small islands. At some later period a gradual elevation occurred, which

ultimately united the whole of the islands with the continent. This may

have continued till the glacial period of the northern hemisphere, during

the severest part of which a few Himalayan species of birds and mammals may

have been driven southward, and {386} have ranged over suitable portions of

the whole area. Java then became separated by subsidence, and these species

were imprisoned in the island; while those in the remaining part of the

Malayan area again migrated northward when the cold had passed away from

their former home, the equatorial forests of Borneo, Sumatra, and the Malay

Peninsula being more especially adapted to the typical Malayan fauna which

is there developed in rich profusion. A little later the subsidence may

have extended farther north, isolating Borneo and Sumatra, in which a few

other Indian or Indo-Chinese forms have been retained, but probably leaving

the Malay Peninsula as a ridge between them as far as the islands of Banca

and Biliton. Other slight changes of climate followed, when a further

subsidence separated these last-named islands from the Malay Peninsula, and

left them with two or three species which have since become slightly

modified. We may thus explain how it is that a species is sometimes common

to Sumatra and Borneo, while the intervening island (Banca) possesses a

distinct form.[92]

In my \_Geographical Distribution of Animals\_, Vol. I., p. 357, I have given

a somewhat different hypothetical explanation of the relations of Java and

Borneo to the continent, in which I took account of changes of land and sea

only; but a fuller consideration of the influence of changes of climate on

the migration of animals, has led me to the much simpler, and, I think,

more probable, explanation above given. The amount of the relationship

between Java and Siam, as well as of that between Java and the Himalayas,

is too small to be well accounted for by an independent geographical

connection in which Borneo and Sumatra did not take part. It is, at the

same time, too distinct and indisputable to be ignored; and a change of

climate which should drive a portion of the Himalayan fauna southward,

leaving a few species in Java and Borneo from which they could not return

owing to the subsequent isolation of those islands by subsidence, seems

{387} to be a cause exactly adapted to produce the kind and amount of

affinity between these distant countries that actually exists.

THE PHILIPPINE ISLANDS.

A general account of the fauna of these islands, and of their biological

relations to the countries which form the subject of this chapter, has been

given in my \_Geographical Distribution of Animals\_, Vol. I. pp. 345-349;

but since the publication of that work considerable additions have been

made to their fauna, having the effect of somewhat diminishing their

isolation from the other islands. Four genera have been added to the

terrestrial mammalia--Crocidura, Felis, Pteromys, and Mus, as well as two

additional squirrels; while the black ape (\_Cynopithecus niger\_) has been

struck out as not inhabiting the Philippines. This brings the true land

mammalia to twenty-one species, of which fourteen are peculiar to the

islands; but to these we must add no less than thirty-three species of bats

of which only ten are peculiar.[93] In these estimates the Palawan {388}

group has been omitted as these islands contain so many Bornean species

that if included they obscure the special features of the fauna.

\_Birds.\_--The late Marquis of Tweeddale made a special study of Philippine

birds, and in 1873 published a catalogue in the \_Transactions of the

Zoological Society\_ (Vol. IX. Pt. 2, pp. 125-247). But since that date

large collections have been made by Everett, Steere, and other travellers,

the result of which has been to more than double the known species, and to

render the ornithological fauna an exceedingly rich one. Many of the

Malayan genera which were thought to be absent when the first edition of

this work was published have since been discovered, among which are

Phyllornis, Criniger, Diceum, Prionochilus, and Batrachostomus. But there

still remain a large number of highly characteristic Malayan genera whose

absence gives a distinctive feature to the Philippine bird fauna. Among

these are Tiga and Meiglyptes, genera of woodpeckers; PhÃ¦nicophaes and

Centropus, remarkable cuckoos; the long-tailed paroquets, PalÃ¦ornis; all

the genera of Barbets except XantholÃ¦ma; the small but beautiful family

EurylÃ¦midÃ¦; many genera allied to Timalia and Ixos; the mynahs, Gracula;

the long-tailed flycatchers, Tchitrea; the fire-backed pheasants,

Euplocamus; the argus pheasants, the jungle-fowl, and many others.

The following tabular statement will illustrate the rapid growth of our

knowledge of the birds of the Philippines:--

|Land-birds.|Water-birds.|Total.

+-----------+------------+------

Lord Tweeddale's Catalogue (1873) | 158 | 60 | 218

Mr. Wardlaw Ramsay's List (1881) | 265 | 75 | 340

Mr. Everett's MSS. List of Additions (1891)| 370 | 102 | 472

The number of peculiar species is very large, there being about 300 land

and forty-two water birds, which are not {389} known to occur beyond the

group. We have here, still more pronounced than in the case of Borneo, the

remarkable fact of the true land birds presenting a larger amount of

speciality than the land mammals; for while more than four-fifths of the

birds are peculiar, only a little more than half the mammals are so, and if

we exclude the bats only two-thirds.

The general character of the fauna of this group of islands is evidently

the result of their physical conditions and geological history. The

Philippines are almost surrounded by deep sea, but are connected with

Borneo by means of two narrow submarine banks, on the northern of which is

situated Palawan, and on the southern the Sulu Islands. Two small groups of

islands, the Bashees and Babuyanes, have also afforded a partial connection

with the continent by way of Formosa. It is evident that the Philippines

once formed part of the great Malayan extension of Asia, but that they were

separated considerably earlier than Java; and having been since greatly

isolated and much broken up by volcanic disturbances, their species have

for the most part become modified into distinct local forms, representative

species often occurring in the different islands of the group. They have

also received a few Chinese types by the route already indicated, and a few

Australian forms owing to their proximity to the Moluccas. Their

comparative poverty in genera and species of the mammalia is perhaps due to

the fact that they have been subjected to a great amount of submersion in

recent times, greatly reducing their area and causing the extinction of a

considerable portion of their fauna. This is not a mere hypothesis, but is

supported by direct evidence; for I am informed by Mr. Everett, who has

made extensive explorations in the islands, that almost everywhere are

found large tracts of elevated coral-reefs, containing shells similar to

those living in the adjacent seas, an indisputable proof of recent

elevation.

\_Concluding Remarks on the Malay Islands.\_--This completes our sketch of

the great Malay islands, the seat of the typical Malayan fauna. It has been

shown that the peculiarities presented by the individual islands may be all

{390} sufficiently well explained by a very simple and comparatively

unimportant series of geographical changes, combined with a limited amount

of change of climate towards the northern tropic. Beginning in late Miocene

times when the deposits on the south coast of Java were upraised, we

suppose a general elevation of the whole of the extremely shallow seas

uniting what are now Sumatra, Java, Borneo, and the Philippines with the

Asiatic continent, and forming that extended equatorial area in which the

typical Malayan fauna was developed. After a long period of stability,

giving ample time for the specialisation of so many peculiar types, the

Philippines were first separated; then at a considerably later period Java;

a little later Sumatra and Borneo; and finally the islands south of

Singapore to Banca and Biliton. This one simple series of elevations and

subsidences, combined with the changes of climate already referred to, and

such local elevations and depressions as must undoubtedly have occurred,

appears sufficient to have brought about the curious, and at first sight

puzzling, relations, of the faunas of Java and the Philippines, as compared

with those of the larger islands.

We will now pass on to the consideration of two other groups which offer

features of special interest, and which will complete our illustrative

survey of recent continental islands.

\* \* \* \* \*

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CHAPTER XVIII

JAPAN AND FORMOSA

Japan, its Position and Physical Features--Zoological Features of

Japan--Mammalia--Birds--Birds Common to Great Britain and Japan--Birds

Peculiar to Japan--Japan Birds Recurring in Distant

Areas--Formosa--Physical Features of Formosa--Animal Life of

Formosa--Mammalia--Land-birds Peculiar to Formosa--Formosan Birds

Recurring in India or Malaya--Comparison of Faunas of Hainan, Formosa,

and Japan--General Remarks on Recent Continental Islands.

JAPAN.

The Japanese Islands occupy a very similar position on the eastern shore of

the great Euro-Asiatic continent to that of the British Islands on the

western, except that they are about sixteen degrees further south, and

having a greater extension in latitude enjoy a more varied as well as a

more temperate climate. Their outline is also much more irregular and their

mountains loftier, the volcanic peak of Fusiyama being 14,177 feet high;

while their geological structure is very complex, their soil extremely

fertile, and their vegetation in the highest degree varied and beautiful.

Like our own islands, too, they are connected with the continent by a

marine bank less than a hundred fathoms below the surface--at all events

towards the north and south; but in the intervening space the Sea of Japan

opens out to a width of six hundred miles, and in its central portion is

very deep, and this may be an indication that the connection between the

islands and the continent is of rather ancient date. At the Straits of

Corea the distance from the main land is about 120 miles, while at the

northern extremity of Yesso it is about 200. The island of Saghalien,

however, separated from Yesso by a strait only twenty-five miles wide,

forms a connection with Amoorland in about 52Â° N. Lat. A southern warm

current flowing a little to the eastward of the islands, ameliorates their

climate much in the same way as the Gulf Stream does ours, and added to

their insular position enables them to support a more tropical vegetation

and more varied forms of life than are found at corresponding latitudes in

China.

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[Illustration: MAP OF JAPAN AND FORMOSA (with depths in fathoms).

Light tint, sea under 100 fathoms. Medium tint, under 1,000 fathoms. Dark

tint, over 1,000 fathoms. The figures show the depth in fathoms.]

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\_Zoological Features of Japan.\_--As we might expect from the conditions

here sketched out, Japan exhibits in all its forms of animal life a close

general resemblance to the adjacent continent, but with a considerable

element of specific individuality; while it also possesses some remarkable

isolated groups. Its fauna presents indications of there having been two or

more lines of migration at different epochs. The majority of its animals

are related to those of the temperate or cold regions of the continent,

either as identical or allied species; but a smaller number have a tropical

character, and these have in several instances no allies in China but occur

again only in Northern India or the Malay Archipelago. There is also a

slight American element in the fauna of Japan, a relic probably of the

period when a land communication existed between the two continents over

what are now the shallow seas of Japan, Ochotsk, and Kamschatka. We will

now proceed to examine the peculiarities and relations of the fauna.

\_Mammalia.\_--The mammalia of Japan at present known are forty in number;

not very many when compared with the rich fauna of China and Manchuria, but

containing monkeys, bears, deer, wild goats and wild boars, as well as

foxes, badgers, moles, squirrels, and hares, so that there can be no doubt

whatever that they imply a land connection with the continent. No complete

account of Japan mammals has been given by any competent zoologist since

the publication of Von Siebold's \_Fauna Japonica\_ in 1844, {394} but by

collecting together most of the scattered observations since that period

the following list has been drawn up, and will, it is hoped, be of use to

naturalists. The species believed to be peculiar to Japan are printed in

italics. These are very numerous, but it must be remembered that Corea and

Manchuria (the portions of the continent opposite Japan) are comparatively

little known, while in very few cases have the species of Japan and of the

continent been critically compared. Where this has been done, however, the

peculiar species established by the older naturalists have been in many

cases found to be correct.

LIST OF THE MAMMALIA OF THE JAPANESE ISLANDS.

1. \_Macacus speciosus.\_ A monkey with rudimentary tail and red face,

allied to the Barbary ape. It inhabits the island of Niphon up to 41Â°

N. Lat., and has thus the most northern range of any living monkey.

2. \_Pteropus dasymallus.\_ A peculiar fruit-bat, found in Kiusiu Island

only (Lat. 33Â° N.), and thus ranging further north of the equator than

any other species of the genus.

3. Rhinolophus ferrum-equinum. The great horse-shoe bat, ranges from

Britain across Europe and temperate Asia to Japan. It is the \_R.

nippon\_ of the Fauna Japonica according to Mr. Dobson's \_Monograph of

Asiatic Bats\_.

4. R. minor. Found also in Burma, Yunan, Java, Borneo, &c.

5. Vesperugo pipistrellus. From Britain across Europe and Asia.

6. V. abramus. Also in India and China.

7. V. noctula. From Britain across Europe and Asia.

8. V. molossus. Also in China.

9. Vespertilio capaccinii. Philippine Islands, and Italy! This is \_V.

macrodactylus\_ of the Fauna Japonica according to Mr. Dobson.

10. Miniopterus schreibersii. Philippines, Burma, Malay Islands. This

is \_Vespertilio blepotis\_ of the Fauna Japonica.

11. \_Talpa wogura.\_ Closely resembles the common mole of Europe, but

has six incisors instead of eight in the lower jaw.

12. \_Talpa mizura.\_ GÃ¼nth. Allied to \_T. wogura\_.

13. \_Urotrichus talpoides.\_ A peculiar genus of moles confined to

Japan. An American species has been named \_Urotrichus gibsii\_, and Mr.

Lord after comparing the two says that he "can find no difference

whatever, either generic or specific. In shape, size, and colour, they

are exactly alike." But Dr. GÃ¼nther (\_P. Z. S.\_ 1880, p. 441) states

that \_U. gibsii\_ differs so much in dentition from the Japanese species

that it should be placed in a distinct genus, which he calls

Neurotrichus.

14. Sorex myosurus. A shrew, found also in India and Malaya.

15. \_Sorex dzi-nezumi.\_

16. \_S. umbrinus.\_

17. \_S. platycephalus.\_ {395}

18. Ursus arctos. var. A peculiar variety of the European brown bear

which inhabits also Amoorland and Kamschatka. It is the \_Ursus ferox\_

of the Fauna Japonica.

19. \_Ursus japonicus.\_ A peculiar species allied to the Himalayan and

Formosan species. Named \_U. tibetanus\_ in the Fauna Japonica.

20. \_Meles anakuma.\_ Differs from the European and Siberian badgers in

the form of the skull.

21. \_Mustela brachyura.\_ A peculiar martin found also in the Kurile

Islands.

22. \_Mustela melanopus.\_ The Japanese sable.

23. \_M. Japonica.\_ A peculiar martin (See \_Proc. Zool. Soc.\_ 1865, p.

104).

24. \_M. Sibericus.\_ Also Siberia and China. This is the \_M. italsi\_ of

the Fauna Japonica according to Dr. Gray.

25. \_Lutronectes whiteleyi.\_ A new genus and species of otter

(\_P. Z. S.\_ 1867, p. 180). In the Fauna Japonica named \_Lutra

vulgaris\_.

26. Enhydris marina. The sea-otter of California and Kamschatka.

27. \_Canis hodophylax.\_ According to Dr. Gray allied to \_Cuon

sumatranus\_ of the Malay Islands, and \_C. alpinus\_ of Siberia, if not

identical with one of them (\_P. Z. S.\_ 1868, p. 500).

28. \_Vulpes japonica.\_ A peculiar fox. \_Canis vulpes\_ of Fauna

Japonica.

29. Nyctereutes procyonoides. The racoon-dog of N. China and Amoorland.

30. \_Lepus brachyurus.\_ A peculiar hare.

31. \_Sciurus lis.\_ A peculiar squirrel.

32. \_Pteromys leucogenys.\_ The white-cheeked flying squirrel.

33. \_P. momoga.\_ Perhaps identical with a Cambojan species (\_P. Z. S.\_

1861, p. 137).

34. \_Myoxus japonicus.\_ A peculiar dormouse. \_M. elegans\_ of the Fauna

Japonica; \_M. javanicus\_, Schinz (\_Synopsis Mammalium\_, ii. p. 530).

35. \_Mus argenteus.\_ China.

36. \_Mus molossinus.\_

37. \_M. nezumi.\_

38. \_M. speciosus.\_

39. \_Cervus sika.\_ A peculiar deer allied to \_C. pseudaxis\_ of Formosa

and \_C. mantchuricus\_ of Northern China.

40. \_Nemorhedus crispa.\_ A goat-like antelope allied to \_N. sumatranus\_

of Sumatra, and \_N. Swinhoei\_ of Formosa.

41. \_Sus leucomystax.\_ A wild boar allied to \_S. taeranus\_ of Formosa.

We thus find that no less than twenty-six out of the forty-one Japanese

mammals are peculiar, and if we omit the aÃ«rial bats (nine in number), as

well as the marine sea-otter, we shall have remaining only thirty strictly

land mammalia, of which twenty-five are peculiar, or five-sixths of the

whole. Nor does this represent all their speciality; for we have a mole

differing in its dentition from the European mole; another superficially

resembling but quite distinct from an American species; a peculiar genus of

otters; and an antelope whose nearest allies are in Formosa and Sumatra.

The importance of these facts will {396} be best understood when we have

examined the corresponding affinities of the birds of Japan.

\_Birds.\_--Owing to the recent researches of some English residents we have

probably a fuller knowledge of the birds than of the mammalia; yet the

number of true land-birds ascertained to inhabit the islands either as

residents or migrants is only 200, which is less than might be expected

considering the highly favourable conditions of mild climate, luxuriant

vegetation, and abundance of insect-life, and the extreme riches of the

adjacent continent,--Mr. Swinhoe's list of the birds of China containing

more than 400 land species, after deducting all which are peculiar to the

adjacent islands. Only seventeen species, or about one-twelfth of the

whole, are now considered to be peculiar to Japan proper; while seventeen

more are peculiar to the various outlying small islands constituting the

Bonin and Loo Choo groups. Even of these, six or seven are classed by Mr.

Seebohm as probably sub-species or slightly modified forms of continental

birds, so that ten only are well-marked species, undoubtedly distinct from

those of any other country.

The great majority of the birds are decidedly temperate forms identical

with those of Northern Asia and Europe; while no less than forty of the

species of land-birds are also found in Britain, or are such slight

modifications of British species that the difference is only perceptible to

a trained ornithologist. The following list of the land-birds common to

Britain and Japan is very interesting, when we consider that these

countries are separated by the whole extent of the European and Asiatic

continents, or by almost exactly one-fourth of the circumference of the

globe:--

LAND BIRDS COMMON TO GREAT BRITAIN AND JAPAN.[94]

(\_Either Identical Species or Representative sub-species.\_)

1. Goldcrest \_Regulus cristatus\_ sub-sp. \_orientalis\_.

2. Marsh tit \_Parus palustris\_ sub-sp. \_japonicus\_.

3. Coal tit \_Parus ater\_ sub-sp. \_pekinensis\_.

4. Long-tailed tit \_Acredula caudata\_ (the sub-sp. \_rosea\_, is

British).

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5. Common creeper \_Certhia familiaris.\_

6. Nuthatch \_Sitta europÃ¦a\_ sub-sp. \_amurensis.\_

7. Carrion crow \_Corvus corone.\_

8. Nutcracker \_Nucifraga caryocatactes.\_

9. Magpie \_Pica caudata.\_

10. Pallass' grey shrike \_Lanius excubitor\_ sub-sp. \_major.\_

11. Waxwing \_Ampelis garrulus.\_

12. Grey wagtail \_Motacilla boarula\_ sub-sp. \_melanope.\_

13. Alpine Pipit \_Anthus spinoletta\_ sub-sp. \_japonicus.\_

14. Skylark \_Alauda arvensis\_ sub-sp. \_japonica.\_

15. Common hawfinch \_Coccothraustes vulgaris.\_

16. Common Crossbill \_Loxia curvirostra.\_

17. Siskin \_Fringilla spinus.\_

18. Mealy redpole ,, \_linaria.\_

19. Brambling ,, \_montifringilla.\_

20. Tree sparrow \_Passer montanus.\_

21. Reed bunting \_Emberiza schoeniculus\_ sub-sp.

\_palustris.\_

22. Rustic bunting ,, \_rustica.\_

23. Snow bunting ,, \_nivalis.\_

24. Chimney swallow \_Hirundo rustica\_ sub-sp. \_gutturalis.\_

25. Sand martin \_Cotyle riparia.\_

26. Great spotted woodpecker \_Picus major\_ sub-sp. \_japonicus.\_

27. Lesser spotted woodpecker ,, \_minor.\_

28. Wryneck \_Jynx torquilla.\_

29. Hoopoe \_Upupa epops.\_

30. Blue rock pigeon \_Columba livia.\_

31. Cuckoo \_Cuculus canorus.\_

32. Kingfisher \_Alcedo ispida\_ sub-sp. \_bengalensis.\_

33. Eagle owl \_Bubo maximus.\_

34. Snowy owl \_Surnia nyctea.\_

35. Long-eared owl \_Strix otus.\_

36. Short-eared owl ,, \_brachyotus.\_

37. Scops owl \_Scops scops.\_

38. Jer falcon \_Falco gyrfalco.\_

39. Peregrine falcon ,, \_peregrinus.\_

40. Hobby ,, \_subbuteo.\_

41. Merlin \_Falco Ã¦salon.\_

42. Kestrel \_Tinnunculus alaudarius\_ sub-sp.

\_japonicus.\_

43. Osprey \_Pandion haliÃ¤ctus.\_

44. Honey-buzzard \_Pernis apivorus.\_

45. White-tailed eagle \_HaliÃ¤etus albicilla.\_

46. Golden eagle \_Aquila chrysÃ¤etus.\_

47. Common buzzard \_Buteo vulgaris\_ sub-sp. \_plumipes.\_

48. Hen-harrier \_Circus cyaneus.\_

49. Marsh-harrier ,, \_Ã¦ruginosus.\_

50. Gos-hawk \_Astur palumbarius.\_

51. Sparrow-hawk \_Accipiter nisus.\_

52. Ptarmigan \_Tetrao mutus.\_

53. Common quail \_Coturnix communis.\_

But even these fifty-three species by no means fairly represent the amount

of \_resemblance\_ between Britain and {398} Japan as regards birds; for

there are also thrushes, robins, stonechats, wrens, hedge-sparrows,

sedge-warblers, jays, starlings, swifts, goatsuckers, and some others,

which, though distinct \_species\_ from our own, have the same general

appearance, and give a familiar aspect to the ornithology. There remains,

however, a considerable body of Chinese and Siberian species, which link

the islands to the neighbouring parts of the continent; and there are also

a few which are Malayan or Himalayan rather than Chinese, and thus afford

us an interesting problem in distribution.

The seventeen species and sub-species which are altogether peculiar to

Japan proper, are for the most part allied to birds of North China and

Siberia, but three are decidedly tropical, and one of them--a fruit pigeon

(\_Treron sieboldi\_)--has no close ally nearer than Burmah and the

Himalayas. In the following list the affinities of the species are

indicated wherever they have been ascertained:--

LIST OF THE SPECIES OF LAND BIRDS PECULIAR TO JAPAN.

1. \_Accentor rubidus.\_ Nearly allied to our hedge-sparrow, and less

closely to the Central Asian \_A. immaculatus.\_

(1a. \_Hypsipetes amaurotis.\_ Migrates to the Corea, otherwise

peculiar.)

2. \_Zosterops japonica.\_ Allied to two Chinese species.

3. \_Lusciniola pryeri.\_

4. \_Garrulus japonicus.\_ Allied to the Siberian and British Jays.

5. \_Fringilla kawarahiba.\_ Allied to the Chinese greenfinch.

6. \_Emberiza ciopsis.\_ Allied to the E. Siberian bunting \_E. cioides\_,

of which it may be considered a sub-species.

7. ,, \_yessoensis.\_ A distinct species.

8. ,, \_personata.\_ A sub-species of \_E. spodocephala.\_

9. \_Gecinus awokera.\_ A distinct species of green woodpecker.

10. \_Picus namiyei.\_ Allied to a Formosan species.

11. \_Treron sieboldi.\_ Allied to \_T. sphenura\_ of the Himalayas, and to

a Formosan species.

12. \_Carpophaga ianthina.\_ A distinct species of fruit-pigeon.

13. \_Bubo blakistoni.\_ Allied to a Philippine eagle-owl.

14. \_Scops semitorgues.\_ A distinct species.

15. \_Phasianus versicolor.\_ A distinct species.

16. ,, \_soemmeringi.\_ A distinct species.

17. ,, \_scintillaus.\_ A sub-species of the last.

The large number of seventeen peculiar species in the outlying Bonin and

Loo Choo Islands is an interesting feature of Japanese ornithology. The

comparative remoteness of {399} these islands, their mild sub-tropical

climate and luxuriant vegetation, and perhaps the absence of violent storms

and their being situated out of the line of continental migration, seem to

be the conditions that have favoured the specialisation of modified types

adapted to the new environment.

\_Japan Birds Recurring in Distant Areas.\_--The most interesting feature in

the ornithology of Japan is, undoubtedly, the presence of several species

which indicate an alliance with such remote districts as the Himalayas, the

Malay Islands, and Europe. Among the peculiar species, the most remarkable

of this class are,--the fruit-pigeon of the genus Treron, entirely unknown

in China, but reappearing in Formosa and Japan; the Hypsipetes, whose

nearest ally is in South China at a distance of nearly 500 miles; and the

jay (\_Garrulus japonicus\_), whose near ally (\_G. glandarius\_) inhabits

Europe only, at a distance of 3,700 miles. But even more extraordinary are

the following non-peculiar species:--\_Spizaetus orientalis\_, a crested

eagle, inhabiting the Himalayas, Formosa, and Japan, but unknown in

Southern or Eastern China; \_Ceryle guttata\_, a spotted kingfisher, almost

confined to the Himalayas and Japan, though occurring rarely in Central

China; and \_Halcyon coromanda\_, a brilliant red kingfisher inhabiting

Northern India, the Malay Islands to Celebes, Formosa, and Japan. We have

here an excellent illustration of the favourable conditions which islands

afford both for species which elsewhere live further south (\_Halcyon

coromanda\_), and for the preservation in isolated colonies of species which

are verging towards extinction; for such we must consider the above-named

eagle and kingfisher, both confined to a very limited area on the

continent, but surviving in remote islands. Referring to our account of the

birth, growth, and death of a species (in Chapter IV.) it can hardly be

doubted that the \_Ceryle guttata\_ formerly ranged from the Himalayas to

Japan, and has now almost died out in the intervening area owing to

geographical and physical changes, a subject which will be better discussed

when we have examined the interesting fauna of the island of Formosa. {400}

The other orders of animals are not yet sufficiently known to enable us to

found any accurate conclusions upon them. The main facts of their

distribution have already been given in my \_Geographical Distribution of

Animals\_ (Vol I., pp. 227-231), and they sufficiently agree with the birds

and mammalia in showing a mixture of temperate and tropical forms with a

considerable proportion of peculiar species. Owing to the comparatively

easy passage from the northern extremity of Japan through the island of

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. In the case of mammals this

is more difficult; and the large proportion of specific difference in their

case is a good indication of the comparatively remote epoch at which Japan

was finally separated from the continent. How long ago this separation took

place we cannot of course tell, but we may be sure it was much longer than

in the case of our own islands, and therefore probably in the earlier

portion of the Pliocene period.

FORMOSA.

Among recent continental islands there is probably none that surpasses in

interest and instructiveness the Chinese island named by the Portuguese,

Formosa, or "The Beautiful." Till quite recently it was a \_terra incognita\_

to naturalists, and we owe almost all our present knowledge of it to a

single man, the late Mr. Robert Swinhoe, who, in his official capacity as

one of our consuls in China, visited it several times between 1856 and

1866, besides residing on it for more than a year. During this period he

devoted all his spare time and energy to the study of natural history, more

especially of the two important groups, birds and mammals; and by employing

a large staff of native collectors and hunters, he obtained a very complete

knowledge of its fauna. In this case, too, we have the great advantage of a

very thorough knowledge of the adjacent parts of the continent, in great

part due to Mr. Swinhoe's own exertions during the twenty years of his

service in {401} that country. We possess, too, the further advantage of

having the whole of the available materials in these two classes collected

together by Mr. Swinhoe himself after full examination and comparison of

specimens; so that there is probably no part of the world (if we except

Europe, North America, and British India) of whose warm-blooded vertebrates

we possess fuller or more accurate knowledge than we do of those of the

coast districts of China and its islands.[95]

\_Physical Features of Formosa.\_--The island of Formosa is nearly half the

size of Ireland, being 220 miles long, and from twenty to eighty miles

wide. It is traversed down its centre by a fine mountain range, which

reaches an altitude of about 8,000 feet in the south and 12,000 feet in the

northern half of the island, and whose higher slopes and valleys are

everywhere clothed with magnificent forests. It is crossed by the line of

the Tropic of Cancer a little south of its centre; and this position,

combined with its lofty mountains, gives it an unusual variety of tropical

and temperate climates. These circumstances are all highly favourable to

the preservation and development of animal life, and from what we already

know of its productions, it seems probable that few, if any islands of

approximately the same size and equally removed from a continent will be

found to equal it in the number and variety of their higher animals. The

outline map (at page 392) shows that Formosa is connected with the mainland

by a submerged bank, the hundred-fathom line including it along with Hainan

to the south-west and Japan on the north-east; while the line of

two-hundred fathoms includes also the Madjico-Sima and Loo-Choo Islands,

and may, perhaps, mark out approximately the last great extension of the

Asiatic continent, the submergence of which isolated these islands from the

mainland.

\_Animal Life of Formosa.\_--We are at present acquainted {402} with 35

species of mammalia, and 128 species of land-birds from Formosa, fourteen

of the former and forty-three of the latter being peculiar, while the

remainder inhabit also some part of the continent or adjacent islands. This

proportion of peculiar species is perhaps (as regards the birds) the

highest to be met with in any island which can be classed as both

continental and recent, and this, in all probability, implies that the

epoch of separation is somewhat remote. It was not, however, remote enough

to reach back to a time when the continental fauna was very different from

what it is now, for we find all the chief types of living Asiatic mammalia

represented in this small island. Thus we have monkeys; insectivora;

numerous carnivora; pigs, deer, antelopes, and cattle among ungulata;

numerous rodents, and the edentate Manis,--a very fair representation of

Asiatic mammals, all being of known genera, and of species either

absolutely identical with some still living elsewhere or very closely

allied to them. The birds exhibit analogous phenomena, with the exception

that we have here two peculiar and very interesting genera.

But besides the amount of specific and generic modification that has

occurred, we have another indication of the lapse of time in the peculiar

relations of a large proportion of the Formosan animals, which show that a

great change in the distribution of Asiatic species must have taken place

since the separation of the island from the continent. Before pointing

these out it will be advantageous to give lists of the mammalia and

peculiar birds of the island, as we shall have frequent occasion to refer

to them.

LIST OF THE MAMMALIA OF FORMOSA. (The peculiar species are printed in

italics.)

1. \_Macacus cyclopis.\_ A rock-monkey more allied to \_M. rhesus\_ of

India than to \_M. sancti-johannis\_ of South China.

2. \_Pteropus formosus.\_ A fruit-bat closely allied to the Japanese

species. None of the genus are found in China.

3. Vesperugo abramus. China.

4. Vespertilio formosus. Black and orange Bat. China.

5. Nyctinomus cestonii. Large-eared Bat. China, S. Europe.

6. \_Talpa insularis.\_ A blind mole of a peculiar species.

{403} 7. Sorex murinus. Musk Rat. China.

8. Sorex sp. A shrew, undescribed.

9. Erinaceus sp. A Hedgehog, undescribed.

10. Ursus tibetanus. The Tibetan Bear. Himalayas and North China.

11. \_Helictis subaurantiaca.\_ The orange-tinted Tree Civet. Allied to

\_H. nipalensis\_ of the Himalayas more than to \_H. moschata\_ of

China.

12. Martes flavigula, var. The yellow-necked Marten. India, China.

13. Felis macroscelis. The clouded Tiger of Siam and Malaya.

14. Felis viverrina. The Asiatic wild Cat. Himalayas and Malacca.

15. Felis chinensis. The Chinese Tiger Cat. China.

16. Viverricula malaccensis. Spotted Civet. China, India.

17. Paguma larvata. Gem-faced Civet. China.

18. \_Sus taivanus.\_ Allied to the wild Pig of Japan.

19. Cervulus reevesii. Reeve's Muntjac. China.

20. \_Cervus pseudaxis.\_ Formosan Spotted Deer. Allied to \_C. sika\_ of

Japan.

21. \_Cervus swinhoii.\_ Swinhoe's Rusa Deer. Allied to Indian and

Malayan species.

22. \_Nemorhedus swinhoii.\_ Swinhoe's Goat-antelope. Allied to the

species of Sumatra and Japan.

23. Bos chinensis. South China wild Cow.

24. Mus bandicota. The Bandicoot Rat. Perhaps introduced from India.

25. Mus indicus. Indian Rat.

26. \_Mus coxinga.\_ Spinous Country-rat.

27. \_Mus canna.\_ Silken Country-rat.

28. \_Mus losca\_. Brown Country-rat.

29. Sciurus castaneoventris. Chestnut-bellied Squirrel. China and

Hainan.

30. Sciurus m'clellandi. McClelland's Squirrel. Himalayas, China.

31. \_Sciuropterus kaleensis.\_ Small Formosan Flying Squirrel. Allied to

\_S. alboniger\_ of Nepal.

32. \_Pteromys grandis.\_ Large Red Flying Squirrel. Allied to Himalayan

and Bornean species. From North Formosa.

33. \_Pteromys pectoralis.\_ White-breasted Flying Squirrel. From South

Formosa.

34. Lepus sinensis. Chinese Hare. Inhabits South China.

35. Manis dalmanni. Scaly Ant-eater. China and the Himalayas.

The most interesting and suggestive feature connected with these Formosan

mammals is the identity or affinity of several of them, with Indian or

Malayan rather than with Chinese species. We have the rock-monkey of

Formosa allied to the rhesus monkeys of India and Burma, not to those of

South China and Hainan. The tree civet (\_Helictis subaurantiaca\_), and the

small flying squirrel (\_Sciuropterus kaleensis\_), are both allied to

Himalayan species. Swinhoe's deer and goat-antelope are nearest to Malayan

species, as are the red and white-breasted flying squirrels; while the

fruit-bat, the wild pig, {404} and the spotted deer are all allied to

peculiar Japanese species. The clouded tiger is a Malay species unknown in

China, while the Asiatic wild cat is a native of the Himalayas and Malacca.

It is clear, therefore, that before Formosa was separated from the mainland

the above named animals or their ancestral types must have ranged over the

intervening country as far as the Himalayas on the west, Japan on the

north, and Borneo or the Philippines on the south; and that after that

event occurred, the conditions were so materially changed as to lead to the

extinction of these species in what are now the coast provinces of China,

while they or their modified descendants continued to exist in the dense

forests of the Himalayas and the Malay Islands, and in such detached

islands as Formosa and Japan. We will now see what additional light is

thrown upon this subject by an examination of the birds.

LIST OF THE LAND BIRDS PECULIAR TO FORMOSA.

TURDIDÃ (Thrushes).

1. \_Turdus albiceps.\_ Allied to Chinese species.

SYLVIDIÃ (Warblers).

2. \_Cisticola volitans.\_ Allied to \_C. schoenicola\_ of India and

China.

3. \_Herbivox cantans.\_ Sub-species of \_H. cantillaus\_ of N. China and

Japan.

4. \_Notodela montium.\_ Allied to \_N. leucura\_ of the Himalayas; no ally

in China.

TIMALIIDÃ (Babblers).

5. \_Pomatorhinus musicus.\_ Allies in S. China and the Himalayas.

6. \_P. erythroenemis.\_ Do. do.

7. \_Garrulax ruficeps.\_ Allied to \_G. albogularis\_ of N. India and East

Thibet, not to the species of S. China (\_G. sannio\_).

8. \_Janthocincla poecilorhyncha.\_ Allied to \_J. coerulata\_ of the

Himalayas. None of the genus in China.

9. \_Trochalopteron taivanus.\_ Allied to a Chinese species.

10. \_Alcippe morrisoniana.\_} Near the Himalayan \_A. nipalensis\_.

11. \_A. brunnea.\_ } None of the genus in China.

12. \_Sibia auricularis.\_ Allied to the Himalayan \_S. capistrata\_. The

genus not known in China.

PANURIDÃ (Bearded Tits, &c.).

13. \_Suthora bulomachus.\_ Allied to the Chinese \_S. suffusa\_.

CINCLIDÃ (Dippers and Whistling Thrushes).

14. \_Myiophoneus insularis.\_ Allied to \_M. horsfieldi\_ of South India.

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PARIDÃ (Tits).

15. \_Parus insperatus.\_ Sub-species of \_P. monticola\_ of the Himalayas

and East Thibet.

16. \_P. castaneiventris.\_ Allied to \_P. varius\_ of Japan.

LIOTRICHIDÃ (Hill Tits).

17. \_Liocichla steerii.\_ A peculiar genus of a specially Himalayan

family, quite unknown in China.

PYCNONOTIDÃ (Bulbuls).

18. \_Pycnonotus (Spizixos) cinereicapillus\_. Very near \_P. semitorques\_

of China.

19. \_Hypsipetes nigerrimus.\_ Allied to \_H. concolor\_ of Assam, not to

\_H. macclellandi\_ of China.

ORIOLIDÃ (Orioles).

20. \_Analcipus ardens.\_ Allied to \_A. traillii\_ of the Himalayas and

Tenasserim.

CAMPEPHAGIDÃ (Caterpillar Shrikes).

21. \_Graucalus rex-pineti.\_ Closely allied to the Indian \_G. macei\_. No

ally in China.

DICRURIDÃ (King Crows).

22. \_Chaptia brauniana.\_ Closely allied to \_C. Ã¦nea\_ of Assam. No ally

in China.

MUSCICAPIDÃ (Flycatchers).

23. \_Cyornis vivida.\_ Allied to \_C. rubeculoides\_ of India.

CORVIDÃ (Jays and Crows).

24. \_Garrulus taivanus.\_ Allied to \_G. sinensis\_ of S. China.

25. \_Urocissa coerulea.\_ A very distinct species from its Indian and

Chinese allies.

26. \_Dendrocitta formosÃ¦.\_ A sub-species of the Chinese \_D. sinensis\_.

PLOCEIDÃ (Weaver Finches).

27. \_Munia formosana.\_ Allied to \_M. rubronigra\_ of India and Burmah.

ALAUDIDÃ (Larks).

28. \_Alauda sala.\_}Allies in South China.

29. \_A. wattersi.\_}

PITTIDÃ (Pittas).

30. \_Pitta oreas.\_ Allied to \_P. cyanoptera\_ of Malaya and S. China.

PICIDÃ (Woodpeckers).

31. \_Picus insularis.\_ Allied to \_P. leuconotus\_ of Japan and Siberia.

MEGALÃMIDÃ.

32. \_MegalÃ¦ma nuchalis.\_ Allied to \_M. oortii\_ of Sumatra and \_M.

faber\_ of Hainan. No allies in China.

CAPRIMULGIDÃ (Goatsuckers).

33. \_Caprimulgus stictomus.\_ A sub-species of \_C. monticolus\_ of India

and China.

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COLUMBIDÃ (Pigeons).

34. \_Treron formosÃ¦.\_ Allied to Malayan species.

35. \_Sphenocercus sororius.\_ Allied to Malay species and to \_S.

sieboldi\_ of Japan. No allies of these two birds inhabit China.

36. \_Chalcophaps formosana.\_ Allied to the Indian species which extends

to Tenasserim and Hainan.

TETRAONIDÃ (Grouse and Partridges).

37. \_Orcoperdix crudigularis.\_ A peculiar genus of partridges.

38. \_Bambusicola sonorivox.\_ Allied to the Chinese \_B. thoracica\_.

39. \_Arcoturnix rostrata.\_ Allied to the Chinese \_A. blakistonii\_.

PHASIANIDÃ (Pheasants).

40. \_Phasianus formosanus.\_ Allied to \_P. torquatus\_ of China.

41. \_Euplocamus swinhoii.\_ A very peculiar and beautiful species allied

to the tropical fire-backed pheasants, and to the silver pheasant of

North China.

STRIGIDÃ (Owls).

42. \_Athene pardalota.\_ Closely allied to a Chinese species.

43. \_Lempigius hambroekii.\_ Allied to a Chinese species.

This list exhibits to us the marvellous fact that more than half the

peculiar species of Formosan birds have their nearest allies in such remote

regions as the Himalayas, South India, the Malay Islands, or Japan, rather

than in the adjacent parts of the Asiatic continent. Fourteen species have

Himalayan allies, and six of these belong to genera which are unknown in

China. One has its nearest ally in the Nilgherries, and five in the Malay

Islands; and of these six, four belong to genera which are not Chinese. Two

have their only near allies in Japan. Perhaps more curious still are those

cases in which, though the genus is Chinese, the nearest allied species is

to be sought for in some remote region. Thus we have the Formosan babbler

(\_Garrulax ruficeps\_) not allied to the species found in South China, but

to one inhabiting North India and East Thibet; while the black bulbul

(\_Hypsipetes nigerrimus\_), is not allied to the Chinese species but to an

Assamese form.

In the same category as the above we must place eight species not peculiar

to Formosa, but which are Indian or Malayan rather than Chinese, so that

they offer examples of discontinuous distribution somewhat analogous to

what {407} we found to occur in Japan. These are enumerated in the

following list.

SPECIES OF BIRDS COMMON TO FORMOSA AND INDIA OR MALAYA, BUT NOT FOUND IN

CHINA.

1. \_Siphia superciliaris.\_ The Rufous-breasted Flycatcher of the S. E.

Himalayas.

2. \_Halcyon coromanda.\_ The Great Red Kingfisher of India, Malaya, and

Japan.

3. \_Palumbus pulchricollis.\_ The Darjeeling Wood-pigeon of the S. E.

Himalayas.

4. \_Turnix dussumieri.\_ The larger Button-quail of India.

5. \_Spizaetus nipalensis.\_ The Spotted Hawk-eagle of Nepal and Assam.

6. \_Lophospiza trivirgata.\_ The Crested Gos-hawk of the Malay Islands.

7. \_Bulaca newarensis.\_ The Brown Wood-owl of the Himalayas.

8. \_Strix candida.\_ The Grass-owl of India and Malaya.

The most interesting of the above are the pigeon and the flycatcher, both

of which are, so far as yet known, strictly confined to the Himalayan

mountains and Formosa. They thus afford examples of discontinuous specific

distribution exactly parallel to that of the great spotted kingfisher,

already referred to as found only in the Himalayas and Japan.

\_Comparison of the Faunas of Hainan, Formosa, and Japan.\_--The island of

Hainan on the extreme south of China, and only separated from the mainland

by a strait fifteen miles wide, appears to have considerable similarity to

Formosa, inasmuch as it possesses seventeen peculiar land-birds (out of 130

obtained by Mr. Swinhoe), two of which are close allies of Formosan

species, while two others are identical. We also find four species whose

nearest allies are in the Himalayas. Our knowledge of this island and of

the adjacent coast of China is not yet sufficient to enable us to form an

accurate judgment of its relations, but it seems probable that it was

separated from the continent at, approximately, the same epoch as Formosa

and Japan, and that the special features of each of these islands are

mainly due to their geographical position. Formosa, being more completely

isolated than either of the others, possesses a larger proportion of

peculiar species of birds, while its tropical situation and lofty mountain

ranges {408} have enabled it to preserve an unusual number of Himalayan and

Malayan forms. Japan, almost equally isolated towards the south, and having

a much greater variety of climate as well as a much larger area, possesses

about an equal number of mammalia with Formosa, and an even larger

proportion of peculiar species. Its birds, however, though more numerous

are less peculiar; and this is probably due to the large number of species

which migrate northwards in summer, and find it easy to enter Japan through

the Kurile Isles or Saghalien.[96] Japan too, is largely peopled by those

northern types which have an unusually wide range, and which, being almost

all migratory, are accustomed to cross over seas of moderate extent. The

regular or occasional influx of these species prevents the formation of

special insular races, such as are almost always produced when a portion of

the population of a species remains for a considerable time completely

isolated. We thus have explained the curious fact, that while the mammalia

of the two islands are almost equally peculiar, (those of Japan being most

so in the present state of our knowledge), the birds of Formosa show a far

greater number of peculiar species than those of Japan.

\_General Remarks on Recent Continental Islands.\_--We have now briefly

sketched the zoological peculiarities of an illustrative series of recent

continental islands, commencing with one of the most recent--Great

Britain--in which the process of formation of peculiar species has only

just commenced, and terminating with Formosa, probably one of the most

ancient of the series, and which accordingly presents us with a very large

proportion of peculiar species, not only in its mammalia, which have no

means of crossing the wide strait which separates it from the mainland, but

also in its birds, many of which are quite able to cross over.

Here, too, we obtain a glimpse of the way in which {409} species die out

and are replaced by others, which quite agrees with what the theory of

evolution assures us must have occurred. On a continent, the process of

extinction will generally take effect on the circumference of the area of

distribution, because it is there that the species comes into contact with

such adverse conditions or competing forms as prevent it from advancing

further. A very slight change will evidently turn the scale and cause the

species to contract its range, and this usually goes on till it is reduced

to a very restricted area, and finally becomes extinct. It may conceivably

happen (and almost certainly has sometimes happened) that the process of

restriction of range by adverse conditions may act in one direction only,

and over a limited district, so as ultimately to divide the specific area

into two separated parts, in each of which a portion of the species will

continue to maintain itself. We have seen that there is reason to believe

that this has occurred in a very few cases both in North America and in

Northern Asia. (\_See\_ pp. 65-68.) But the same thing has certainly occurred

in a considerable number of cases, only it has resulted in the divided

areas being occupied by \_representative forms\_ instead of by the very same

species. The cause of this is very easy to understand. We have already

shown that there is a large amount of local variation in a considerable

number of species, and we may be sure that were it not for the constant

intermingling and intercrossing of the individuals inhabiting adjacent

localities this tendency to local variation in adaptation to slightly

different conditions, would soon form distinct races. But as soon as the

area is divided into two portions the intercrossing is stopped, and the

usual result is that two closely allied races, classed as representative

species, become formed. Such pairs of allied species on the two sides of a

continent, or in two detached areas, are very numerous; and their existence

is only explicable on the supposition that they are descendants of a parent

form which once occupied an area comprising that of both of them,--that

this area then became discontinuous,--and, lastly, that, as a consequence

of the discontinuity, the two sections of the parent species became

segregated into distinct races or new species. {410}

Now, when the division of the area leaves one portion of the species in an

island, a similar modification of the species, either in the island or in

the continent, occurs, resulting in closely-allied but distinct forms; and

such forms are, as we have seen, highly characteristic of island-faunas.

But islands also favour the occasional preservation of the unchanged

species--a phenomenon which very rarely occurs in continents. This is

probably due to the absence of competition in islands, so that the parent

species there maintains itself unchanged, while the continental portion, by

the force of that competition, is driven back to some remote mountain area,

where it also obtains a comparative freedom from competition. Thus may be

explained the curious fact, that the species common to Formosa and India

are generally confined to limited areas in the Himalayas, or in other cases

are found only in remote islands, as Japan or Hainan.

The distribution and affinities of the animals of continental islands thus

throws much light on that obscure subject--the decay and extinction of

species; while the numerous and delicate gradations in the modification of

the continental species, from perfect identity, through slight varieties,

local forms, and insular races, to well-defined species and even distinct

genera, afford an overwhelming mass of evidence in favour of the theory of

"descent with modification."

We shall now pass on to another class of islands, which, though originally

forming parts of continents, were separated from them at very remote

epochs. This antiquity is clearly manifested in their existing faunas,

which present many peculiarities, and offer some most curious problems to

the student of distribution.

\* \* \* \* \*

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CHAPTER XIX

ANCIENT CONTINENTAL ISLANDS: THE MADAGASCAR GROUP

Remarks on Ancient Continental Islands--Physical Features of

Madagascar--Biological Features of

Madagascar--Mammalia--Reptiles--Relation of Madagascar to Africa--Early

History of Africa and Madagascar--Anomalies of Distribution and How to

Explain Them--The Birds of Madagascar as Indicating a Supposed Lemurian

Continent--Submerged Islands between Madagascar and India--Concluding

Remarks on "Lemuria"--The Mascarene Islands--The Comoro Islands--The

Seychelles Archipelago--Birds of the Seychelles--Reptiles and

Amphibia--Freshwater Fishes--Land Shells--Mauritius, Bourbon, and

Rodriguez--Birds--Extinct Birds and their Probable

Origin--Reptiles--Flora of Madagascar and the Mascarene

Islands--Curious Relations of Mascarene Plants--Endemic Genera of

Mauritius and Seychelles--Fragmentary Character of the Mascarene

Flora--Flora of Madagascar Allied to that of South

Africa--Preponderance of Ferns in the Mascarene Flora--Concluding

Remarks on the Madagascar Group.

We have now to consider the phenomena presented by a very distinct class of

islands--those which, although once forming part of a continent, have been

separated from it at a remote epoch when its animal forms were very unlike

what they are now. Such islands preserve to us the record of a by-gone

world,--of a period when many of the higher types had not yet come into

existence and when the distribution of others was very different from what

prevails at the present day. The problem presented by these ancient islands

is often complicated by the changes they themselves have undergone since

the period of their separation. A partial subsidence will have led to the

{412} extinction of some of the types that were originally preserved, and

may leave the ancient fauna in a very fragmentary state; while subsequent

elevations may have brought it so near to the continent that some

immigration even of mammalia may have taken place. If these elevations and

subsidences occurred several times over, though never to such an extent as

again to unite the island with the continent, it is evident that a very

complex result might be produced; for besides the relics of the ancient

fauna, we might have successive immigrations from surrounding lands

reaching down to the era of existing species. Bearing in mind these

possible changes, we shall generally be able to arrive at a fair

conjectural solution of the phenomena of distribution presented by these

ancient islands.

Undoubtedly the most interesting of such islands, and that which exhibits

their chief peculiarities in the greatest perfection, is Madagascar, and we

shall therefore enter somewhat fully into its biological and physical

history.

\_Physical Features of Madagascar.\_--This great island is situated about 250

miles from the east coast of Africa, and extends from 12Â° to 25Â½Â° S. Lat.

It is almost exactly 1,000 miles long, with an extreme width of 360 and an

average width of more than 260 miles. A lofty granitic plateau, from eighty

to 160 miles wide and from 3,000 to 5,000 feet high, occupies its central

portion, on which rise peaks and domes of basalt and granite to a height of

nearly 9,000 feet; and there are also numerous extinct volcanic cones and

craters. All round the island, but especially developed on the south and

west, are plains of a few hundred feet elevation, formed of rocks which are

shown by their fossils to be of Jurassic age, or at all events to belong to

somewhere near the middle portion of the Secondary period. The higher

granitic plateau consists of bare undulating moors, while the lower

Secondary plains are more or less wooded; and there is here also a

continuous belt of dense forest, varying from six or eight to fifty miles

wide, encircling the whole island, usually at about thirty miles distance

from the coast but in the north-east coming down to the sea-shore. {413}

[Illustration]

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The sea around Madagascar, when the shallow bank on which it stands is

passed, is generally deep. This 100-fathom bank is only from one to three

miles wide on the east side, but on the west it is much broader, and

stretches out opposite Mozambique to a distance of about eighty miles. The

Mozambique Channel is rather more than 1,000 fathoms deep, but there is

only a narrow belt of this depth opposite Mozambique, and still narrower

where the Comoro Islands and adjacent shoals seem to form stepping-stones

to the continent of Africa. The 1,000-fathom line includes Aldabra and the

small Farquhar Islands to the north of Madagascar; while to the east the

sea deepens rapidly to the 1,000-fathom line and then more slowly, a

profound channel of 2,400 fathoms separating Madagascar from Bourbon and

Mauritius. To the north-east of Mauritius are a series of extensive shoals

forming four large banks less than 100 fathoms below the surface, while the

1,000-fathom line includes them all, with an area about half that of

Madagascar itself. A little further north is the Seychelles group, also

standing on an extensive 1,000-fathom bank, while all round the sea is more

than 2,000 fathoms deep.

It seems probable, then, that to the north-east of Madagascar there was

once a series of very large islands, separated from it by not very wide

straits; while eastward across the Indian Ocean we find the Chagos and

Maldive coral atolls, perhaps marking the position of other large islands,

which together would form a line of communication, by comparatively easy

stages of 400 or 500 miles each between Madagascar and India. These

submerged islands, as shown in our map at p. 424, are of great importance

in explaining some anomalous features in the zoology of this great island.

If the rocks of Secondary age which form a belt around the island are held

to indicate that Madagascar was once of less extent than it is now (though

this by no means necessarily follows), we have also evidence that it has

recently been considerably larger; for along the east coast there is an

extensive barrier coral-reef about 350 miles in length, and varying in

distance from the land from a quarter of a mile to three or four miles.

This seems to indicate recent subsidence; while we have no record of raised

coral rocks inland which would certainly mark any recent elevation, though

fringing coral reefs surround a considerable portion of the northern,

eastern, and south-western coasts. We may therefore conclude that during

Tertiary times the island was usually as large as, and often probably much

larger than, it is now. {415}

[Illustration: MAP OF THE MADAGASCAR GROUP, SHOWING DEPTHS OF SEA.]

In this Map the depth of the sea is shown by three tints; the lightest tint

indicating from 0 to 100 fathoms, the medium tint from 100 to 1,000

fathoms, the dark tint more than 1,000 fathoms.

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\_Biological Features of Madagascar.\_--Madagascar possesses an exceedingly

rich and beautiful fauna and flora, rivalling in some groups most tropical

countries of equal extent, and even when poor in species, of surpassing

interest from the singularity, the isolation, or the beauty of its forms of

life. In order to exhibit the full peculiarity of its natural history and

the nature of the problems it offers to the biological student, we must

give an outline of its more important animal forms in systematic order.

\_Mammalia.\_--Madagascar possesses no less than sixty-six species of

mammals--a certain proof in itself that the island has once formed part of

a continent; but the character of these animals is very extraordinary and

altogether different from the assemblage now found in Africa or in any

other existing continent. Africa is now most prominently characterised by

its monkeys, apes, and baboons; by its lions, leopards, and hyÃ¦nas; by its

zebras, rhinoceroses, elephants, buffaloes, giraffes, and numerous species

of antelopes. But no one of these animals, nor any thing like them, is

found in Madagascar, and thus our first impression would be that it could

never have been united with the African continent. But, as the tigers, the

bears, the tapirs, the deer, and the numerous squirrels of Asia are equally

absent, there seems no probability of its having been united with that

continent. Let us then see to what groups the mammalia of Madagascar

belong, and where we must look for their probable allies.

First and most important are the lemurs, consisting of six genera and

thirty-three species, thus comprising just half the entire mammalian

population of the island. This group of lowly-organised and very ancient

creatures {417} still exists scattered over a wide area; but they are

nowhere so abundant as in the island of Madagascar. They are found from

West Africa to India, Ceylon, and the Malay Archipelago, consisting of a

number of isolated genera and species, which appear to maintain their

existence by their nocturnal and arboreal habits, and by haunting dense

forests. It can hardly be said that the African forms of lemurs are more

nearly allied to those of Madagascar than are the Asiatic, the whole series

appearing to be the disconnected fragments of a once more compact and

extensive group of animals.

Next, we have about a dozen species of Insectivora, consisting of one

shrew, a group distributed over all the great continents; and five genera

of a peculiar family, CentetidÃ¦, which family exists nowhere else on the

globe except in the two largest West Indian Islands, Cuba and Hayti, thus

adding still further to our embarrassment in seeking for the original home

of the Madagascar fauna.

We then come to the Carnivora, which are represented by a peculiar cat-like

animal, Cryptoprocta, forming a distinct family, and having no close allies

in any part of the globe; and eight civets belonging to four peculiar

genera. Here we first meet with some decided indications of an African

origin; for the civet family is more abundant in this continent than in

Asia, and some of the Madagascar genera seem to be decidedly allied to

African groups--as, for example, Eupleres to Suricata and Crossarchus.[97]

The Rodents consist only of four rats and mice of peculiar genera, one of

which is said to be allied to an American genus; and lastly we have a

river-hog of the African genus PotamochÃ¦rus, and a small sub-fossil

hippopotamus, both of which being semi-aquatic animals might easily have

reached the island from Africa, by way of the Comoros, without any actual

land connection.[98]

\_Reptiles of Madagascar.\_--Passing over the birds for the present, as not

so clearly demonstrating {418} land-connection, let us see what indications

are afforded by the reptiles. The large and universally distributed family

of Colubrine snakes is represented in Madagascar, not by African or Asiatic

genera, but by two American genera--Philodryas and Heterodon, and by

Herpetodryas, a genus found in America and China. The other genera are all

peculiar, and belong mostly to widespread tropical families; but two

families--LycodontidÃ¦ and ViperidÃ¦, both abundant in Africa and the Eastern

tropics--are absent. Lizards are mostly represented by peculiar genera of

African or tropical families, but several African genera are represented by

peculiar species, and there are also some species belonging to two American

genera of the IguanidÃ¦, a family which is exclusively American; while a

genus of geckoes, inhabiting America and Australia, also occurs in

Madagascar.

\_Relation of Madagascar to Africa.\_--These facts taken all together are

certainly very extraordinary, since they show in a considerable number of

cases as much affinity with America as with Africa; while the most striking

and characteristic groups of animals now inhabiting Africa are entirely

wanting in Madagascar. Let us first deal with this fact, of the absence of

so many of the most dominant African groups. The explanation of this

deficiency is by no means difficult, for the rich deposits of fossil

mammals of Miocene or Pliocene age in France, Germany, Greece, and

North-west India, have demonstrated the fact that all the great African

mammals then inhabited Europe and temperate Asia. We also know that a

little earlier (in Eocene times) tropical Africa was cut off from Europe

and Asia by a sea stretching from the Atlantic to the Bay of Bengal, at

which time Africa must have formed a detached island-continent such as

Australia is now, and probably, like it, very poor in the higher forms of

life. Coupling these two facts, the inference seems clear, that all the

higher types of mammalia were developed in the great Euro-Asiatic continent

(which then included Northern Africa), and that they only migrated into

tropical Africa when the two continents became united by the upheaval of

the sea-bottom, probably {419} in the latter portion of the Miocene or

early in the Pliocene period.[99]

It is clear, therefore, that if Madagascar had once formed part of Africa,

but had been separated from it before Africa was united to Europe and Asia,

it would not contain any of those kinds of animals which then first entered

the country. But, besides the African mammals, we know that some birds now

confined to Africa then inhabited Europe, and we may therefore fairly

assume that all the more important groups of birds, reptiles, and insects,

now abundant in Africa but absent from Madagascar, formed no part of the

original African fauna, but entered the country only after it was joined to

Europe and Asia.

\_Early History of Africa and Madagascar.\_--We have seen that Madagascar

contains an abundance of mammals, and that most of them are of types either

peculiar to, or existing also in, Africa; it follows that that continent

must have had an earlier union with Europe, Asia, or America, or it could

never have obtained any mammals at all.

{420} Now these ancient African mammals are Lemurs, Insectivora, and small

Carnivora, chiefly ViverridÃ¦; and all these groups are known to have

inhabited Europe in Eocene and Miocene times; and that the union was with

Europe rather than with America is clearly proved by the fact that even the

insectivorous CentetidÃ¦, now confined to Madagascar and the West Indies,

inhabited France in the Lower Miocene period, while the ViverridÃ¦, or

civets, which form so important a part of the fauna of Madagascar as well

as of Africa, were abundant in Europe throughout the whole Tertiary period,

but are not known to have ever lived in any part of the American continent.

We here see the application of the principle which we have already fully

proved and illustrated (Chapter IV., p. 60), that all extensive groups have

a wide range at the period of their maximum development; but as they decay

their area of distribution diminishes or breaks up into detached fragments,

which one after another disappear till the group becomes extinct. Those

animal forms which we now find isolated in Madagascar and other remote

portions of the globe all belong to ancient groups which are in a decaying

or nearly extinct condition, while those which are absent from it belong to

more recent and more highly-developed types, which range over extensive and

continuous areas, but have had no opportunity of reaching the more ancient

continental islands.

\_Anomalies of Distribution and How to Explain Them.\_--If these

considerations have any weight, it follows that there is no reason whatever

for supposing any former direct connection between Madagascar and the

Greater Antilles merely because the insectivorous CentetidÃ¦ now exist only

in these two groups of islands; for we know that the ancestors of this

family must once have had a much wider range, which almost certainly

extended over the great northern continents. We might as reasonably suppose

a land-connection across the Pacific to account for the camels of Asia

having their nearest existing allies in the llamas and alpacas of the

Peruvian Andes, and another between Sumatra and Brazil, in order that the

ancestral tapir of one country might have passed over to the other. In both

{421} these cases we have ample proof of the former wide extension of the

group. Extinct camels of numerous species abounded in North America in

Miocene, Pliocene, and even Post-pliocene times, and one has also been

found in North-western India, but none whatever among all the rich deposits

of mammalia in Europe. We are thus told, as clearly as possible, that from

the North American continent as a centre the camel tribe spread westward,

over now-submerged land at the shallow Behring Straits and Kamschatka Sea,

into Asia, and southward along the Andes into South America. Tapirs are

even more interesting and instructive. Their remotest known ancestors

appear in Western Europe in the early portion of the Eocene period; in the

latter Eocene and the Miocene other forms occur both in Europe and North

America. These seem to have become extinct in North America, while in

Europe they developed largely into many forms of true tapirs, which at a

much later period found their way again to North, and thence to South,

America, where their remains are found in caves and gravel deposits. It is

an instructive fact that in the Eastern continent, where they were once so

abundant, they have dwindled down to a single species, existing in small

numbers in the Malay Peninsula, Sumatra, and Borneo only; while in the

Western continent, where they are comparatively recent immigrants, they

occupy a much larger area, and are represented by three or four distinct

species. Who could possibly have imagined such migrations, and extinctions,

and changes of distribution as are demonstrated in the case of the tapirs,

if we had only the distribution of the existing species to found an opinion

upon? Such cases as these--and there are many others equally striking--show

us with the greatest distinctness how nature has worked in bringing about

the examples of anomalous distribution that everywhere meet us; and we

must, on every ground of philosophy and common sense, apply the same method

of interpretation to the more numerous instances of anomalous distribution

we discover among such groups as reptiles, birds, and insects, where we

rarely have any direct evidence of their past migrations through the

discovery of {422} fossil remains. Whenever we can trace the past history

of any group of terrestrial animals, we invariably find that its actual

distribution can be explained by migrations effected by means of

comparatively slight modifications of our existing continents. In no single

case have we any direct evidence that the distribution of land and sea has

been radically changed during the whole lapse of the Tertiary and Secondary

periods, while, as we have already shown in our fifth chapter, the

testimony of geology itself, if fairly interpreted, upholds the same theory

of the stability of our continents and the permanence of our oceans. Yet so

easy and pleasant is it to speculate on former changes of land and sea with

which to cut the gordian knot offered by anomalies of distribution, that we

still continually meet with suggestions of former continents stretching in

every direction across the deepest oceans, in order to explain the presence

in remote parts of the globe of the same genera even of plants or of

insects--organisms which possess such exceptional facilities both for

terrestrial, aÃ«rial, and oceanic transport, and of whose distribution in

early geological periods we generally know little or nothing.

\_The Birds of Madagascar, as Indicating a Supposed Lemurian

Continent.\_--Having thus shown how the distribution of the land mammalia

and reptiles of Madagascar may be well explained by the supposition of a

union with Africa before the greater part of its existing fauna had reached

it, we have now to consider whether, as some ornithologists think, the

distribution and affinities of the birds present an insuperable objection

to this view, and require the adoption of a hypothetical

continent--Lemuria--extending from Madagascar to Ceylon and the Malay

Islands.

There are about one hundred and fifty land birds known from the island of

Madagascar, of which a hundred and twenty-seven are peculiar; and about

half of these peculiar species belong to peculiar genera, many of which are

extremely isolated, so that it is often difficult to class them in any of

the recognised families, or to determine their affinities to any living

birds.[100] Among the other moiety, {423} belonging to known genera, we

find fifteen which have undoubted African affinities, while five or six are

as decidedly Oriental, the genera or nearest allied species being found in

India or the Malay Islands. It is on the presence of these peculiar Indian

types that Dr. Hartlaub, in his recent work on the \_Birds of Madagascar and

the Adjacent Islands\_, lays great stress, as proving the former existence

of "Lemuria"; while he considers the absence of such peculiar African

families as the plantain-eaters, glossy-starlings, ox-peckers, barbets,

honey-guides, hornbills, and bustards--besides a host of peculiar African

genera--as sufficiently disproving the statement in my \_Geographical

Distribution of Animals\_ that Madagascar is "more nearly related to the

Ethiopian than to any other region," and that its fauna was evidently

"mainly derived from Africa."

But the absence of the numerous peculiar groups of African birds is so

exactly parallel to the same phenomenon among mammals, that we are

justified in imputing it to the same cause, the more especially as some of

the very groups that are wanting--the plantain-eaters and the trogons, for

example,--are actually known to have inhabited Europe along with the large

mammalia which subsequently migrated to Africa. As to the peculiarly

Eastern genera--such as Copsychus and Hypsipetes, with a Dicrurus, a

Ploceus, a Cisticola, and a Scops, all closely allied to Indian or Malayan

species--although very striking to the ornithologist, they certainly do not

outweigh the fourteen African genera found in Madagascar. Their presence

may, moreover, be accounted for more satisfactorily than by means of an

ancient Lemurian continent, which, even if granted, would not explain the

very facts adduced in its support.

Let us first prove this latter statement.

The supposed "Lemuria" must have existed, if at all, at so remote a period

that the higher animals did not then inhabit either Africa or Southern

Asia, and it must have {424} become partially or wholly submerged before

they reached those countries; otherwise we should find in Madagascar many

other animals besides Lemurs, Insectivora, and ViverridÃ¦, especially such

active arboreal creatures as monkeys and squirrels, such hardy grazers as

deer or antelopes, or such wide-ranging carnivores as foxes or bears. This

obliges us to date the disappearance of the hypothetical continent about

the earlier part of the Miocene epoch at latest, for during the latter part

of that period we know that such animals existed in abundance in every part

of the great northern continents wherever we have found organic remains.

But the Oriental birds in Madagascar, by whose presence Dr. Hartlaub

upholds the theory of a Lemuria, are slightly modified forms of \_existing

Indian genera\_, or sometimes, as Dr. Hartlaub himself points out, \_species

hardly distinguishable from those of India\_. Now all the evidence at our

command leads us to conclude that, even if these genera and species were in

existence in the early Miocene period, they must have had a widely

different distribution from what they have now. Along with so many African

and Indian genera of mammals they then probably inhabited Europe, which at

that epoch enjoyed a sub-tropical climate; and this is rendered almost

certain by the discovery in the Miocene of France of fossil remains of

trogons and jungle-fowl. If, then, these Indian birds date back to the very

period during which alone Lemuria could have existed, that continent was

quite unnecessary for their introduction into Madagascar, as they could

have followed the same track as the mammalia of Miocene Europe and Asia;

while if, as I maintain, they are of more recent date, then Lemuria had

ceased to exist, and could not have been the means of their introduction.

\_Submerged Islands between Madagascar and India.\_--Looking at the

accompanying map of the Indian Ocean, we see that between Madagascar and

India there are now extensive shoals and coral reefs, such as are usually

held to indicate subsidence; and we may therefore fairly postulate the

former existence here of several large islands, some of them not much

inferior to Madagascar itself. These reefs are all separated from each

other by very deep {425} sea--much deeper than that which divides

Madagascar from Africa, and we have therefore no reason to imagine their

former union. But they would nevertheless greatly facilitate the

introduction of Indian birds into the Mascarene Islands and Madagascar; and

these facilities existing, such an immigration would be sure to take place,

just as surely as American birds have entered the Galapagos and Juan

Fernandez, as European birds now reach the Azores, and as Australian birds

reach such a distant island as New Zealand. This would take place the more

certainly because the Indian Ocean is a region of violent periodical storms

at the changes of the monsoons, and we have seen in the case of the Azores

and Bermuda how important a factor this is in determining the transport of

birds across the ocean.

[Illustration: MAP OF THE INDIAN OCEAN.

Showing the position of banks less than 1,000 fathoms deep between Africa

and the Indian Peninsula.]

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The final disappearance of these now sunken islands does not, in all

probability, date back to a very remote epoch; and this exactly accords

with the fact that some of the birds, as well as the fruit-bats of the

genus Pteropus, are very closely allied to Indian species, if not actually

identical, others being distinct species of the same genera. The fact that

not one closely-allied species or even genus of Indian or Malayan mammals

is found in Madagascar, sufficiently proves that it is no land-connection

that has brought about this small infusion of Indian birds and bats; while

we have sufficiently shown, that, when we go back to remote geological

times no land-connection in this direction was necessary to explain the

phenomena of the distribution of the Lemurs and Insectivora. A

land-connection with \_some\_ continent was undoubtedly necessary, or there

would have been no mammalia at all in Madagascar; and the nature of its

fauna on the whole, no less than the moderate depth of the intervening

strait and the comparative approximation of the opposite shores, clearly

indicate that the connection was with Africa.

\_Concluding Remarks on "Lemuria."\_--I have gone into this question in some

detail, because Dr. Hartlaub's criticism on my views has been reproduced in

a scientific periodical,[101] and the supposed Lemurian continent is

constantly referred to by quasi-scientific writers, as well as by

naturalists and geologists, as if its existence had been demonstrated by

facts, or as if it were absolutely necessary to postulate such a land in

order to account for the entire series of phenomena connected with the

Madagascar fauna, and especially with the distribution of the

LemuridÃ¦.[102] I {427} think I have now shown, on the other hand, that it

was essentially a provisional hypothesis, very useful in calling attention

to a remarkable series of problems in geographical distribution, but not

affording the true solution of those problems, any more than the hypothesis

of an Atlantis solved the problems presented by the Atlantic Islands and

the relations of the European and North American flora and fauna. The

Atlantis is now rarely introduced seriously except by the absolutely

unscientific, having received its death-blow by the chapter on Oceanic

Islands in the \_Origin of Species\_, and the researches of Professor Asa

Gray on the affinities of the North American and Asiatic floras. But

"Lemuria" still keeps its place--a good example of the survival of a

provisional hypothesis which offers what seems an easy solution of a

difficult problem, and has received an appropriate and easily remembered

name, long after it has been proved to be untenable.

It is now more than fifteen years since I first showed, by a careful

examination of all the facts to be accounted for, that the hypothesis of a

Lemurian continent was alike unnecessary to explain one portion of the

facts, and inadequate to explain the remaining portion.[103] Since that

time I have seen no attempt even to discuss the question on general grounds

in opposition to my views, nor on the other hand have those who have

hitherto supported the hypothesis taken any opportunity of acknowledging

its weakness and inutility. I have therefore here explained my reasons for

rejecting it somewhat more fully and in a more popular form, in the hope

that a check may thus be placed on the continued re-statement of this

unsound theory as if it were one of the accepted conclusions of modern

science.

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\_The Mascarene Islands.\_[104]--In the \_Geographical Distribution of

Animals\_, a summary is given of all that was known of the zoology of the

various islands near Madagascar, which to some extent partake of its

peculiarities, and with it form the Malagasy sub-region of the Ethiopian

region. As no great additions have since been made to our knowledge of the

fauna of these islands, and my object in this volume being more especially

to illustrate the mode of solving distributional problems by means of the

most suitable examples, I shall now confine myself to pointing out how far

the facts presented by these outlying islands support the views already

enunciated with regard to the origin of the Madagascar fauna.

\_The Comoro Islands.\_--This group of islands is situated nearly midway

between the northern extremity of Madagascar and the coast of Africa. The

four chief islands vary between sixteen and forty miles in length, the

largest being 180 miles from the coast of Africa, while one or two smaller

islets are less than 100 miles from Madagascar. All are volcanic, Great

Comoro being an active volcano 8,500 feet high; and, as already stated,

they are situated on a submarine bank with less than 500 fathoms soundings,

connecting Madagascar with Africa. There is reason to believe, however,

that these islands are of comparatively recent origin, and that the bank

has been formed by matter ejected by the volcanoes or by upheaval. Anyhow,

there is no indication whatever of there having been here a land-connection

between Madagascar and Africa; while the islands themselves have been

mainly colonised from Madagascar, some of them making a near approach to

the 100-fathom bank which surrounds that island.

The Comoros contain two land mammals, a lemur and a civet, both of

Madagascar genera and the latter an identical species, and there is also a

peculiar species of fruit-bat (\_Pteropus comorensis\_), a group which ranges

from Australia to Asia and Madagascar but is unknown in Africa. Of

land-birds forty-one species are known, of {429} which sixteen are peculiar

to the islands, twenty-one are found also in Madagascar, and three found in

Africa and not in Madagascar; while of the peculiar species, six belong to

Madagascar or Mascarene genera. A species of Chameleon is also peculiar to

the islands.

These facts point to the conclusion that the Comoro Islands have been

formerly more nearly connected with Madagascar than they are now, probably

by means of intervening islets and the former extension of the latter

island to the westward, as indicated by the extensive shallow bank at its

northern extremity, so as to allow of the easy passage of birds, and the

occasional transmission of small mammalia by means of floating trees.[105]

\_The Seychelles Archipelago.\_--This interesting group consists of about

thirty small islands situated 700 miles N.N.E. of Madagascar, or almost

exactly in the line formed by continuing the central ridge of that great

island. The Seychelles stand upon a rather extensive shallow bank, the

100-fathom line around them enclosing an area nearly 200 miles long by 100

miles wide, while the 500-fathom line shows an extension of nearly 100

miles in a southern direction. All the larger islands are of granite, with

mountains rising to 3,000 feet in MahÃ©, and to from 1,000 to 2,000 feet in

several of the other islands. We can therefore hardly doubt that they form

a portion of the great line of upheaval which produced the central granitic

mass of Madagascar, intervening points being indicated by the Amirantes,

the Providence, and the Farquhar Islands, which, though all coralline,

probably rest on a granitic basis. Deep channels of more than 1,000 fathoms

now separate these islands from each other, and if they were ever

sufficiently elevated to be united, it was probably at a very remote epoch.

The Seychelles may thus have had ample facilities for receiving from

Madagascar such immigrants as can pass over narrow seas; and, on the other

hand, they were equally favourably situated as regards the extensive Saya

de Malha and Cargados banks, which were probably once {430} large islands,

and may have supported a rich insular flora and fauna of mixed Mascarene

and Indian type. The existing fauna and flora of the Seychelles must

therefore be looked upon as the remnants which have survived the partial

submergence of a very extensive island; and the entire absence of

non-aÃ«rial mammalia may be due, either to this island having never been

actually united to Madagascar, or to its having since undergone so much

submergence as to have led to the extinction of such mammals as may once

have inhabited it. The birds and reptiles, however, though few in number,

are very interesting, and throw some further light on the past history of

the Seychelles.

\_Birds of the Seychelles.\_--Fifteen indigenous land-birds are known to

inhabit the group, thirteen of which are peculiar species,[106] belonging

to genera which occur also in Madagascar or Africa. The genera which are

more peculiarly Indian are,--Copsychus and Hypsipetes, also found in

Madagascar; and PalÃ¦ornis, which has species in Mauritius and Rodriguez, as

well as one on the continent of Africa. A black parrot (Coracopsis),

congeneric with two species that inhabit Madagascar and with one that is

peculiar to the Comoros; and a beautiful red-headed blue pigeon

(\_AlectorÃ¦nas pulcherrimus\_) allied to those of Madagascar and Mauritius,

but very distinct, are the most remarkable species characteristic of this

group of islands.

\_Reptiles and Amphibia of the Seychelles.\_--The reptiles and amphibia are

rather numerous and very interesting, indicating clearly that the islands

can hardly be classed as oceanic. There are seven species of lizards, three

being peculiar to the islands, while the others have rather a wide range.

The first is a chameleon--defenceless {431} slow-moving lizards, especially

abundant in Madagascar, from which no less than eighteen species are now

known, about the same number as on the continent of Africa. The Seychelles

species (\_ChamÃ¦leon tigris\_) also occurs at Zanzibar. The next are skinks

(ScincidÃ¦), small ground-lizards with a wide distribution in the Eastern

hemisphere. Two species are however peculiar to the islands--\_Mabuia

seychellensis\_ and \_M. wrightii\_. The other peculiar species is one of the

geckoes (GeckotidÃ¦) named \_Ãluronyx seychellensis\_, and there are also

three other geckoes, \_Phelsuma madagascarensis\_, \_Gehyra mutilata\_ and

\_Hemidactylus frenatus\_, the two latter having a wide distribution in the

tropical regions of both hemispheres. These lizards, clinging as they do to

trees and timber, are exceedingly liable to be carried in ships from one

country to another, and I am told by Dr. GÃ¼nther that some are found almost

every year in the London Docks. It is therefore probable, that when species

of this family have a very wide range they have been assisted in their

migrations by man, though their habit of clinging to trees also renders

them likely to be floated with large pieces of timber to considerable

distances. Dr. Percival Wright, to whom I am indebted for much information

on the productions of the Seychelles Archipelago, informs me that the

last-named species varies greatly in colour in the different islands, so

that he could always tell from which particular island a specimen had been

brought. This is analogous to the curious fact of certain lizards on the

small islands in the Mediterranean being always very different in colour

from those of the mainland, usually becoming rich blue or black (see

\_Nature\_, Vol. XIX. p. 97); and we thus learn how readily in some cases

differences of colour are brought about, either directly or indirectly, by

local conditions.

Snakes, as is usually the case in small or remote islands, are far less

numerous than lizards, only two species being known. One, \_Dromicus

seychellensis\_, is a peculiar species of the family ColubridÃ¦, the rest of

the genus being found in Madagascar and South America. The other, \_Boodon

geometricus\_, one of the LycodontidÃ¦, or fanged ground-snakes, is also

peculiar. So far, then, as the reptiles are {432} concerned, there is

nothing but what is easily explicable by what we know of the general means

of distribution of these animals.

We now come to the Amphibia, which are represented in the Seychelles by two

tailless and two serpent-like forms. The frogs are \_Rana mascareniensis\_,

found also in Mauritius, Bourbon, Angola, and Abyssinia, and probably all

over tropical Africa; and \_Megalixalus seychellensis\_ a peculiar tree-frog

having allies in Madagascar and tropical Africa. It is found, Dr. Wright

informs me, on the Pandani or screw-pines; and as these form a very

characteristic portion of the vegetation of the Mascarene Islands, all the

species being peculiar and confined each to a single island or small group,

we may perhaps consider it as a relic of the indigenous fauna of that more

extensive land of which the present islands are the remains.

The serpentine Amphibia are represented by two species of CÃ¦cilia. These

creatures externally resemble large worms, except that they have a true

head with jaws and rudimentary eyes, while internally they have of course a

true vertebrate skeleton. They live underground, burrowing by means of the

ring-like folds of the skin which simulate the jointed segments of a worm's

body, and when caught they exude a viscid slime. The young have external

gills which are afterwards replaced by true lungs, and this peculiar

metamorphosis shows that they belong to the amphibia rather than to the

reptiles. The CÃ¦cilias are widely but very sparingly distributed through

all the tropical regions; a fact which may, as we have seen, be taken as an

indication of the great antiquity of the group, and that it is now verging

towards extinction. In the Seychelles Islands there appear to be three

species of these singular animals. \_Cryptopsophis multiplicatus\_ is

confined to the islands; \_Herpele squalostoma\_ is found also in Western

India and in Africa; while \_Hypogeophis rostratus\_ inhabits both West

Africa and South America.[107] This last is certainly one of the most

remarkable cases of the wide and discontinuous distribution of a species;

and {433} when we consider the habits of life of these animals and the

extreme slowness with which it is likely they can migrate into new areas,

we can hardly arrive at any other conclusion than that this species once

had an almost world-wide range, and that in the process of dying out it has

been left stranded, as it were, in these three remote portions of the

globe. The extreme stability and long persistence of specific form which

this implies is extraordinary, but not unprecedented, among the lower

vertebrates. The crocodiles of the Eocene period differ but slightly from

those of the present day, while a small freshwater turtle from the Pliocene

deposits of the Siwalik Hills is absolutely identical with a still living

Indian species, \_Emys tectus\_. The mud-fish of Australia, \_Ceratodus

forsteri\_ is a very ancient type, and may well have remained specifically

unchanged since early Tertiary times. It is not, therefore, incredible that

this Seychelles CÃ¦cilia may be the oldest land vertebrate now living on the

globe; dating back to the early part of the Tertiary period, when the warm

climate of the northern hemisphere in high latitudes and the union of the

Asiatic and American continents allowed of the migration of such types over

the whole northern hemisphere, from which they subsequently passed into the

southern hemisphere, maintaining themselves only in certain limited areas,

where the physical conditions were especially favourable, or where they

were saved from the attacks of enemies or the competition of higher forms.

\_Fresh-water Fishes.\_--The only other vertebrates in the Seychelles are two

fresh-water fishes abounding in the streams and rivulets. One, \_Haplochilus

playfairii\_ is peculiar to the islands, but there are allied species in

Madagascar. It is a pretty little fish about four inches long, of an olive

colour, with rows of red spots, and is very abundant in some of the

mountain streams. The fishes of this genus, as I am informed by Dr.

GÃ¼nther, often inhabit both sea and fresh water, so that their migration

from {434} Madagascar to the Seychelles and subsequent modification, offers

no difficulty. The other species is \_Fundulus orthonotus\_, found also on

the east coast of Africa; and as both belong to the same

family--CyprinodontidÃ¦--this may possibly have migrated in a similar

manner.

\_Land-shells.\_--The only other group of animals inhabiting the Seychelles

which we know with any approach to completeness, are the land and

fresh-water mollusca, but they do not furnish any facts of special

interest. About forty species are known, and Mr. Geoffrey Nevill, who has

studied them, thinks their meagre number is chiefly owing to the

destruction of so much of the forests which once covered the islands. Seven

of the species--and among them one of the most conspicuous, \_Achatina

fulica\_--have almost certainly been introduced; and the remainder show a

mixture of Madagascar and Indian forms, with a preponderance of the latter.

Five genera--Streptaxis, Cyathoponea, Onchidium, Helicina and Paludomus,

are mentioned as being especially Indian, while only two--Tropidophora and

Gibbus, are found in Madagascar but not in India.[108] About two-thirds of

the species appear to be peculiar to the islands.

\_Mauritius, Bourbon and Rodriguez.\_--These three islands are somewhat out

of place in this chapter, because they really belong to the oceanic group,

being of volcanic formation, surrounded by deep sea, and possessing no

indigenous mammals or amphibia. Yet their productions are so closely

related to those of Madagascar, to which they may be considered as

attendant satellites, that it is absolutely necessary to associate them

together if we wish to comprehend and explain their many interesting

features.

Mauritius and Bourbon are lofty volcanic islands, evidently of great

antiquity. They are about 100 miles apart, and the sea between them is less

than 1,000 fathoms deep, while on each side it sinks rapidly to depths of

2,400 and 2,600 fathoms. We have therefore no reason to believe that they

have ever been connected with {435} Madagascar, and this view is strongly

supported by the character of their indigenous fauna. Of this, however, we

have not a very complete or accurate knowledge, for though both islands

have long been occupied by Europeans, the study of their natural products

was for a long time greatly neglected, and owing to the rapid spread of

sugar cultivation, the virgin forests, and with them no doubt many native

animals, have been almost wholly destroyed. There is, however, no good

evidence of there ever having been any indigenous mammals or amphibia,

though both are now found and are often recorded among the native

animals.[109]

The smaller and more remote island, Rodriguez, is also volcanic; but it

has, besides a good deal of coralline rock, an indication of partial

submergence helping to account for the poverty of its fauna and flora. It

stands on a 100-fathom bank of considerable extent, but beyond this the

{436} sea rapidly deepens to more than 2,000 fathoms, so that it is truly

oceanic like its larger sister isles.

\_Birds.\_--The living birds of these islands are few in number and consist

mainly of peculiar species of Mascarene types, together with two peculiar

genera--Oxynotus belonging to the CampephagidÃ¦ or caterpillar-catchers, a

family abundant in the old-world tropics; and a dove, Trocazza, forming a

peculiar sub-genus. The origin of these birds offers no difficulty, looking

at the position of the islands and of the surrounding shoals and islets.

\_Extinct Birds.\_--These three islands are, however, preeminently remarkable

as having been the home of a group of large ground-birds, quite incapable

of flight, and altogether unlike anything found elsewhere on the globe; and

which, though once very abundant, have become totally extinct within the

last two hundred years. The best known of these birds is the dodo, which

inhabited Mauritius; while allied species certainly lived in Bourbon and

Rodriguez, abundant remains of the species of the latter island--the

"solitaire," having been discovered, corresponding with the figure and

description given of it by Legouat, who resided in Rodriguez in 1692. These

birds constitute a distinct family, DididÃ¦, allied to the pigeons but very

isolated. They were quite defenceless, and were rapidly exterminated when

man introduced dogs, pigs, and cats into the island, and himself sought

them for food. The fact that such perfectly unprotected creatures survived

in great abundance to a quite recent period in these three islands only,

while there is no evidence of their ever having inhabited any other

countries whatever, is itself almost demonstrative that Mauritius, Bourbon,

and Rodriguez are very ancient but truly oceanic islands. From what we know

of the general similarity of Miocene birds to living genera and families,

it seems clear that the origin of so remarkable a type as the dodos must

date back to early Tertiary times. If we suppose some ancestral

ground-feeding pigeon of large size to have reached the group by means of

intervening islands afterwards submerged, and to have thenceforth remained

to increase and multiply unchecked by the attacks of any more {437}

powerful animals, we can well understand that the wings, being useless,

would in time become almost aborted.[110] It is also not improbable that

this process would be aided by natural selection, because the use of wings

might be absolutely prejudicial to the birds in their new home. Those that

flew up into trees to roost, or tried to cross over the mouths of rivers,

might be blown out to sea and destroyed, especially during the hurricanes

which have probably always more or less devastated the islands; while on

the other hand the more bulky and short-winged individuals, who took to

sleeping on the ground in the forest, would be preserved from such dangers,

and perhaps also from the attacks of birds of prey which may always have

visited the islands. But whether or no this was the mode by which these

singular birds acquired their actual form and structure, it is perfectly

certain that their existence and development depended on complete isolation

and on freedom from the attacks of enemies. We have no single example of

such defenceless birds having ever existed on a continent at any geological

period, whereas analogous though totally distinct forms do exist in New

Zealand, where enemies are equally wanting. On the other hand, every

continent has always produced abundance of carnivora adapted to prey upon

the herbivorous animals inhabiting it at the same period; and we may

therefore be sure that {438} these islands have never formed part of a

continent during any portion of the time when the dodos inhabited them.

It is a remarkable thing that an ornithologist of Dr. Hartlaub's

reputation, looking at the subject from a purely ornithological point of

view, should yet entirely ignore the evidence of these wonderful and unique

birds against his own theory, when he so confidently characterises Lemuria

as "that sunken land, which, containing parts of Africa, must have extended

far eastward over Southern India and Ceylon, and the highest points of

which we recognise in the volcanic peaks of Bourbon and Mauritius, and in

the central range of Madagascar itself--the last resorts of the mostly

extinct Lemurine race which formerly peopled it."[111] It is here implied

that lemurs formerly inhabited Bourbon and Mauritius, but of this there is

not a particle of evidence, and we feel pretty sure that had they done so

the dodos would never have been developed there. In Madagascar there are no

traces of dodos, while there are remains of extinct gigantic struthious

birds of the genus Ãpyornis, which were no doubt as well able to protect

themselves against the smaller carnivora as are the ostriches, emus, and

cassowaries in their respective countries at the present day.

The whole of the evidence at our command, therefore, tends to establish in

a very complete manner the "oceanic" character of the three

islands--Mauritius, Bourbon, and Rodriguez, and that they have never formed

part of "Lemuria" or of any continent.

\_Reptiles.\_--Mauritius, like Bourbon, has lizards, some of which are

peculiar species; but no snakes, and no frogs or toads but such as have

been introduced.[112] Strange to say, however, a small islet called Round

Island, only about a mile across, and situated about fourteen miles

north-east of Mauritius, possesses a snake which is not only unknown in

Mauritius, but also in any other part of the world, being {439} altogether

confined to this minute islet! It belongs to the boa family, and forms a

peculiar and very distinct genus, Casaria, whose nearest allies seem to be

the Ungalia of Cuba and Bolyeria of Australia. It is hardly possible to

believe that this serpent has very long maintained itself on so small an

island; and though we have no record of its existence on Mauritius, it may

very well have inhabited the lowland forests without being met with by the

early settlers; and the introduction of swine, which soon ran wild and

effected the final destruction of the dodo, may also have been fatal to

this snake. It is, however, now almost certainly confined to the one small

islet, and is probably the land-vertebrate of most restricted distribution

on the globe.

On the same island there is a small lizard, \_Scelotes bojeri\_, recorded

also from Mauritius and Bourbon, though it appears to be rare in both

islands; but a gecko, \_Phelsuma guentheri\_, is restricted to the island. As

Round Island is connected with Mauritius by a bank under a hundred fathoms

below the surface, it has probably been once joined to it, and when first

separated would have been both much larger and much nearer the main island,

circumstances which would greatly facilitate the transmission of these

reptiles to their present dwelling-place, where they have been able to

maintain themselves owing to the complete absence of competition, while

some of them have become extinct in the larger island.

\_Flora of Madagascar and the Mascarene Islands.\_--The botany of the great

island of Madagascar has been perhaps more thoroughly explored than that of

the opposite coasts of Africa, so that its peculiarities may not be really

so great as they now appear to be. Yet there can be no doubt of its extreme

richness and grandeur, its remarkable speciality, and its anomalous

external relations. It is characterised by a great abundance of

forest-trees and shrubs of peculiar genera or species, and often adorned

with magnificent flowers. Some of these are allied to African forms, others

to those of Asia, and it is said that of the two affinities the latter

preponderates. But there are also, as in the animal world, some decided

South {440} American relations, while other groups point to Australia, or

are altogether isolated.

No less than 3,740 flowering plants are now known from Madagascar with 360

ferns and fern-allies. The most abundant natural orders are the following:

Species.

LeguminosÃ¦ 346

Ferns 318

CompositÃ¦ 281

EuphorbiaceÃ¦ 228

OrchideÃ¦ 170

CyperaceÃ¦ 160

RubiaceÃ¦ 147

AcanthaceÃ¦ 131

GramineÃ¦ 130

The flora contains representatives of 144 natural orders and 970 genera,

one of the former and 148 of the latter being peculiar to the island. The

peculiar order, ChÃ¦lnaceÃ¦, comprises seven genera and twenty-four species;

while RubiaceÃ¦ and CompositÃ¦ have the largest number of peculiar genera,

followed by LeguminosÃ¦ and MelastomaceÃ¦. Nearly three-fourths of the

species are endemic.

Beautiful flowers are not conspicuous in the flora of Madagascar, though it

contains several magnificent flowering plants. A shrub with the dreadful

name \_Harpagophytum Grandidieri\_ has bunches of gorgeous red flowers;

\_Tristellateia madagascariensis\_ is a climbing plant with spikes of rich

yellow flowers; while \_Poinciana regia\_, a tall tree, \_RhodolÃ¦na altivola\_

and \_Astrapoea Wallichii\_, shrubs, are among the most magnificent flowering

plants in the world. \_Disa Buchenaviana\_, \_Commelina madagascarica\_, and

\_Tachiadenus platypterus\_ are fine blue-flowered plants, while the superb

orchid \_AngrÃ¦cum sesquipedale\_, \_Vinca rosea\_, \_Euphorbia splendens\_, and

\_Stephanotis floribunda\_, have been long cultivated in our hot-houses.

There are also many handsome CombretaceÃ¦, RubiaceÃ¦, and LeguminosÃ¦; but, as

in most tropical regions, this wealth of floral beauty has to be searched

for, and produces little effect in the landscape.

The affinities of the Madagascar flora are to a great extent in accordance

with those of the fauna. The tropical portion of the flora agrees closely

with that of tropical Africa, while the plants of the highlands are {441}

equally allied to those of the Cape and of the mountains of Central Africa.

Some Asiatic types are present which do not occur in Africa; and even the

curious American affinities of some of the animals are reproduced in the

vegetable kingdom. These last are so interesting that they deserve to be

enumerated. An American genus of EuphorbiaceÃ¦, Omphalea, has one species in

Madagascar, and Pedilanthus, another genus of the same natural order, has a

similar distribution. Myrosma, an American genus of ScitamineÃ¦ has one

Madagascar species; while the celebrated "travellers' tree," \_Ravenala

madagascariensis\_, belonging to the order MusaceÃ¦, has its nearest ally in

a plant inhabiting N. Brazil and Guiana. EchinolÃ¦na, a genus of grasses,

has the same distribution.[113]

Of the flora of the smaller Madagascarian islands we possess a fuller

account, owing to the recent publication of Mr. Baker's \_Flora of the

Mauritius and the Seychelles\_, including also Rodriguez. The total number

of species in this flora is 1,058, more than half of which (536) are

exclusively Mascarene--that is, found only in some of the islands of the

Madagascar group, while nearly a third (304) are endemic or confined to

single islands. Of the widespread plants sixty-six are found in Africa but

not in Asia, and eighty-six in Asia but not in Africa, showing a similar

Asiatic preponderance to what is said to occur in Madagascar. With the

genera, however, the proportions are different, for I find by going through

the whole of the generic distributions as given by Mr. Baker, that out of

the 440 genera of wild plants fifty are endemic, twenty-two are Asiatic but

not African, while twenty-eight are African but not Asiatic. This implies

that the more ancient connection has been on the side of Africa, while a

more recent immigration, shown by identity of species, has come from the

side of Asia; and it is already certain that when the flora of Madagascar

is more thoroughly worked out, a still greater African preponderance will

be found in that island.

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A few Mascarene genera are found elsewhere only in South America,

Australia, or Polynesia; and there are also a considerable number of genera

whose metropolis is South America, but which are represented by one or more

species in Madagascar, and by a single often widely distributed species in

Africa. This fact throws light upon the problem offered by those mammals,

reptiles, and insects of Madagascar which now have their only allies in

South America, since the two cases would be exactly parallel were the

African plants to become extinct. Plants, however, are undoubtedly more

long-lived specifically than animals--especially the more highly organised

groups, and are less liable to complete extinction through the attacks of

enemies or through changes of climate or of physical geography; hence we

find comparatively few cases in which groups of Madagascar plants have

their \_only\_ allies in such distant regions as America and Australia, while

such cases are numerous among animals, owing to the extinction of the

allied forms in intervening areas, for which extinction, as we have already

shown, ample cause can be assigned.

\_Curious Relations of Mascarene Plants.\_--Among the curious affinities of

Mascarene plants we have culled the following from Mr. Baker's volume.

Trochetia, a genus of SterculiaceÃ¦, has four species in Mauritius, one in

Madagascar, and one in the remote island of St. Helena. Mathurina, a genus

of TurneraceÃ¦, consisting of a single species peculiar to Rodriguez, has

its nearest ally in another monotypic genus, Erblichia, confined to Central

America. Siegesbeckia, one of the CompositÃ¦, consists of two species, one

inhabiting the Mascarene islands, the other Peru. Labourdonasia, a genus of

SapotaceÃ¦, has two species in Mauritius, one in Natal, and one in Cuba.

Nesogenes, belonging to the verbena family, has one species in Rodriguez

and one in Polynesia. Mespilodaphne, an extensive genus of LauraceÃ¦, has

six species in the Mascarene islands, and all the rest (about fifty

species) in South America. Nepenthes, the well-known pitcher plants, are

found chiefly in the Malay Islands, South China, and Ceylon, with species

in the Seychelles Islands, {443} and in Madagascar. Milla, a large genus of

LiliaceÃ¦, is exclusively American, except one species found in Mauritius

and Bourbon. Agauria, a genus of EricaceÃ¦, is found in Madagascar, the

Mascarene islands, the plateau of Central Africa, and the Camaroon

Mountains in West Africa. An acacia, found in Mauritius and Bourbon (\_A.

heterophylla\_), can hardly be separated specifically from \_Acacia koa\_ of

the Sandwich Islands. The genus Pandanus, or screw-pine, has sixteen

species in the three islands--Mauritius, Rodriguez, and the Seychelles--all

being peculiar, and none ranging beyond a single island. Of palms there are

fifteen species belonging to ten genera, and all these genera are peculiar

to the islands. We have here ample evidence that plants exhibit the same

anomalies of distribution in these islands as do the animals, though in a

smaller proportion; while they also exhibit some of the transitional stages

by which these anomalies have, in all probability, been brought about,

rendering quite unnecessary any other changes in the distribution of sea

and land than physical and geological evidence warrants.[114]

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\_Fragmentary Character of the Mascarene Flora.\_--Although the peculiar

character and affinities of the vegetation of these islands is sufficiently

apparent, there can be little doubt that we only possess a fragment of the

rich flora which once adorned them. The cultivation of sugar, and other

tropical products, has led to the clearing away of the virgin forests from

all the lowlands, plateaus, and accessible slopes of the mountains, so that

remains of the aboriginal woodlands only linger in the recesses of the

hills, and numbers of forest-haunting plants must inevitably have been

exterminated. The result is, that nearly three hundred species of foreign

plants have run wild in Mauritius, and have in their turn helped to

extinguish the native {445} species. In the Seychelles, too, the indigenous

flora has been almost entirely destroyed in most of the islands, although

the peculiar palms, from their longevity and comparative hardiness, have

survived. Mr. Geoffrey Nevill tells us, that at MahÃ©, and most of the other

islands visited by him, it was only in a few spots near the summits of the

hills that he could perceive any remains of the ancient flora. Pine-apples,

cinnamon, bamboos, and other plants have obtained a firm footing, covering

large tracts of country and killing the more delicate native flowers and

ferns. The pine-apple, especially, grows almost to the tops of the

mountains. Where the timber and shrubs have been destroyed, the water

falling on the surface immediately cuts channels, runs off rapidly, and

causes the land to become dry and arid; and the same effect is largely seen

both in Mauritius and Bourbon, where, originally, dense forest covered the

entire surface, and perennial moisture, with its ever-accompanying

luxuriance of vegetation, prevailed.

\_Flora of Madagascar Allied to that of South Africa.\_--In my \_Geographical

Distribution of Animals\_ I have remarked on the relation between the

insects of Madagascar and those of south temperate Africa, and have

speculated on a great \_southern\_ extension of the continent at the time

when Madagascar was united with it. As supporting this view I now quote Mr.

Bentham's remarks on the CompositÃ¦. He says: "The connections of the

Mascarene endemic CompositÃ¦, especially those of Madagascar itself, are

eminently with the southern and sub-tropical African races; the more

tropical races, PlucheineÃ¦, &c., may be rather more of an Asiatic type." He

further says that the Composite flora is almost as strictly endemic as that

of the Sandwich Islands, and that it is much diversified, with evidences of

great antiquity, while it shows insular characteristics in the tendency to

tall shrubby or arborescent forms in several of the endemic or prevailing

genera.

\_Preponderance of Ferns in the Mascarene Flora.\_--A striking character of

the flora of these smaller Mascarene islands is the great preponderance of

ferns, and next to them of orchideÃ¦. The following figures are taken from

{446} Mr. Baker's \_Flora\_ for Mauritius and the Seychelles, and from an

estimate by M. Frappier of the flora of Bourbon given in Maillard's volume

already quoted:--

\_Mauritius, &c.\_ \_Bourbon.\_

Ferns 168 Ferns 240

OrchideÃ¦ 79 OrchideÃ¦ 120

GramineÃ¦ 69 GramineÃ¦ 60

CyperaceÃ¦ 62 CompositÃ¦ 60

RubiaceÃ¦ 57 LeguminosÃ¦ 36

EuphorbiaceÃ¦ 45 RubiaceÃ¦ 24

CompositÃ¦ 43 CyperaceÃ¦ 24

LeguminosÃ¦ 41 EuphorbiaceÃ¦ 18

The cause of the great preponderance of ferns in oceanic islands has

already been discussed in my book on \_Tropical Nature\_; and we have seen

that Mauritius, Bourbon, and Rodriguez must be classed as such, though from

their proximity to Madagascar they have to be considered as satellites to

that great island. The abundance of orchids, the reverse of what occurs in

remoter oceanic islands, may be in part due to analogous causes. Their

usually minute and abundant seeds would be as easily carried by the wind as

the spores of ferns, and their frequent epiphytic habit affords them an

endless variety of stations on which to vegetate, and at the same time

removes them in a great measure from the competition of other plants. When,

therefore, the climate is sufficiently moist and equable, and there is a

luxuriant forest vegetation, we may expect to find orchids plentiful on

such tropical islands as possess an abundance of insects adapted to

fertilise them, and which are not too far removed from other lands or

continents from which their seeds might be conveyed.

\_Concluding Remarks on Madagascar and the Mascarene Islands.\_--There is

probably no portion of the globe that contains within itself so many and

such varied features of interest connected with geographical distribution,

or which so well illustrates the mode of solving the problems it presents,

as the comparatively small insular region which comprises the great island

of Madagascar and the smaller islands and island-groups which immediately

surround it. 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 {447} 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 Isles, 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 2,500 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.

It is most interesting and satisfactory to find that this conclusion,

arrived at solely by a study of the form of the sea-bottom and the general

principle of oceanic permanence, is fully supported by the evidence of the

organic productions of the several islands; because it gives us confidence

in those principles, and helps to supply us with a practical demonstration

of them. We find that the entire group contains just that amount of Indian

forms which could well have passed from island to island; that many of

these forms are slightly modified species, indicating that the migration

occurred during late Tertiary times, while others are distinct genera,

indicating a more ancient connection; but in no one case do we find animals

which necessitate an actual land-connection, while the numerous Indian

types of mammalia, reptiles, birds, and insects, which must certainly have

passed over had there been such an actual land-connection, are totally

wanting. The one fact which has been supposed to require such a

connection--the distribution of the lemurs--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

(Herpetodryas, &c.) of Madagascar and America; and the lizards

(Cryptoblepharus) of Mauritius and Australia. To suppose, in all these

cases, and in many others, a direct land-connection, is really absurd,

because {448} 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 PalÃ¦ozoic--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.

By very good evidence (the occurrence of wide areas of marine deposits of

Eocene age), geologists have established the fact that Africa was cut off

from Europe and Asia by an arm of the sea in early Tertiary times, forming

a large island-continent. By the evidence of abundant organic remains we

know that all the types of 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; and at this period

it 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 Ãpyornis, its isolated birds,

its remarkable insects, and its rich and peculiar flora. From it the

adjacent islands received such organisms as could cross the sea; while they

transmitted to Madagascar some of the Indian birds and insects which had

reached them.

The method we have followed in these investigations is to accept the

results of geological and palÃ¦ontological science, and the ascertained

facts as to the powers of dispersal of the various animal groups; to take

full account of the laws of evolution as affecting distribution, {449} and

of the various ocean depths as implying recent or remote union of islands

with their adjacent continents; and the result is, that wherever we possess

a sufficient knowledge of these various classes of evidence, we find it

possible to give a connected and intelligible explanation of all the most

striking peculiarities of the organic world. In Madagascar we have

undoubtedly one of the most difficult of these problems; but we have, I

think, fairly met and conquered most of its difficulties. The complexity of

the organic relations of this island is due, partly to its having derived

its animal forms from two distinct sources--from one continent through a

direct land-connection, and from another by means of intervening islands

now submerged; but, mainly to the fact of its having been separated from a

continent which is now, zoologically, in a very different condition from

that which prevailed at the time of the separation; and to its having been

thus able to preserve a number of types which may date back to the Eocene,

or even to the Cretaceous, period. Some of these types have become

altogether extinct elsewhere; others have spread far and wide over the

globe, and have survived only in a few remote countries--and especially in

those which have been more or less secured by their isolated position from

the incursions of the more highly-developed forms of later times. This

explains why it is that the nearest allies of the Madagascar fauna and

flora are now so often to be found in South America or Australia--countries

in which low forms of mammalia and birds still largely prevail;--it being

on account of the long-continued isolation of all these countries that

similar forms (descendants of ancient types) are preserved in them. Had the

numerous suggested continental extensions connecting these remote

continents at various geological periods been realities, the result would

have been that all these interesting archaic forms, all these defenceless

insular types, would long ago have been exterminated, and one comparatively

monotonous fauna have reigned over the whole earth. So far from explaining

the anomalous facts, the alleged continental extensions, had they existed,

would have left no such facts to be explained.

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CHAPTER XX

ANOMALOUS ISLANDS: CELEBES

Anomalous Relations of Celebes--Physical Features of the

Island--Zoological Character of the Islands Around Celebes--The Malayan

and Australian Banks--Zoology of Celebes: Mammalia--Probable Derivation

of the Mammals of Celebes--Birds of Celebes--Bird-types Peculiar to

Celebes--Celebes not Strictly a Continental Island--Peculiarities of

the Insects of Celebes--Himalayan Types of Birds and Butterflies in

Celebes--Peculiarities of Shape and Colour of Celebesian

Butterflies--Concluding Remarks--Appendix on the Birds of Celebes.

The only other islands of the globe which can be classed as "ancient

continental" are the larger Antilles (Cuba, Haiti, Jamaica, and Porto

Rico), Iceland, and perhaps Celebes. The Antilles have been so fully

discussed and illustrated in my former work, and there is so little fresh

information about them, that I do not propose to treat of them here,

especially as they fall short of Madagascar in all points of biological

interest, and offer no problems of a different character from such as have

already been sufficiently explained.

Iceland, also, must apparently be classed as belonging to the "Ancient

Continental Islands," for though usually described as wholly volcanic, it

is, more probably, an island of varied geological structure buried under

the lavas of its numerous volcanoes. But of late years extensive Tertiary

deposits of Miocene age have been discovered, showing that it is not a mere

congeries of {451} volcanoes; it is connected with the British Islands and

with Greenland by seas less than 500 fathoms deep; and it possesses a few

mammalia, one of which is peculiar, and at least three peculiar species of

birds. It was therefore almost certainly united with Greenland, and

probably with Europe by way of Britain, in the early part of the Tertiary

period, and thus afforded one of the routes by which that intermigration of

American and European animals and plants was effected which we know

occurred during some portion of the Eocene and Miocene periods, and

probably also in the Pliocene. The fauna and flora of this island are,

however, so poor, and offer so few peculiarities, that it is unnecessary to

devote more time to their consideration.

There remains the great Malay island--Celebes, which, owing to its

possession of several large and very peculiar mammalia, must be classed,

zoologically, as "ancient continental"; but whose central position and

relations both to Asia and to Australia render it very difficult to decide

in which of the primary zoological regions it ought to be placed, or

whether it has ever been united with either of the great continents.

Although I have pretty fully discussed its zoological peculiarities and

past history in my \_Geographical Distribution of Animals\_, it seems

advisable to review the facts on the present occasion, more especially as

the systematic investigation of the characteristics of continental islands

we have now made will place us in a better position for determining its

true zoo-geographical relations.

\_Physical Features of Celebes.\_--This large and still comparatively

unexplored island is interesting to the geographer on account of its

remarkable outline, but much more so to the zoologist for its curious

assemblage of animal forms. The geological structure of Celebes is almost

unknown. The extremity of the northern peninsula is volcanic; while in the

southern peninsula there are extensive deposits of a crystalline limestone,

in some places overlying basalt. Gold is found in the northern peninsula

and in the central mass, as well as iron, tin, and copper in small

quantities; so that there can be little {452} doubt that the mountain

ranges of the interior consist of ancient stratified rocks.

[Illustration: MAP OF CELEBES AND THE SURROUNDING ISLANDS.

The depth of sea is shown by three tints: the lightest indicating less than

100 fathoms, the medium tint less than 1,000 fathoms, and the dark tint

more than 1,000 fathoms. The figures show depths in fathoms.]

It is not yet known whether Celebes is completely separated from the

surrounding islands by a deep sea, but {453} the facts at our command

render it probable that it is so. The northern and eastern portions of the

Celebes Sea have been ascertained to be from 2,000 to 2,600 fathoms deep,

and such depths may extend over a considerable portion of it, or even be

much exceeded in the centre. In the Molucca passage a single sounding on

the Gilolo side gave 1,200 fathoms, and a large part of the Molucca and

Banda Seas probably exceed 2,000 fathoms. The southern portion of the

Straits of Macassar is full of coral reefs, and a shallow sea of less than

100 fathoms extends from Borneo to within about forty miles of the western

promontory of Celebes; but farther north there is deep water close to the

shore, and it seems probable that a deep channel extends quite through the

straits, which have no doubt been much shallowed by the deposits from the

great Bornean rivers as well as by those of Celebes itself. Southward

again, the chain of volcanic islands from Bali to Timor appears to rise out

of a deep ocean, the few soundings we possess showing depths of from 670 to

1,300 fathoms almost close to their northern shores. We seem justified,

therefore, in concluding that Celebes is entirely surrounded by a deep sea,

which has, however, become partially filled up by river deposits, by

volcanic upheaval, or by coral reefs. Such shallows, where they exist, may

therefore be due to antiquity and isolation, instead of being indications

of a former union with any of the surrounding islands.

\_Zoological Character of the Islands around Celebes.\_--In order to have a

clear conception of the peculiar character of the Celebesian fauna, we must

take into account that of the surrounding countries from which we may

suppose it to have received immigrants. These we may divide broadly into

two groups, those on the west belonging to the Oriental region of our

zoological geography, and those on the east belonging to the Australian

region. Of the first group Borneo is a typical representative; and from its

proximity and the extent of its opposing coasts it is the island which we

should expect to show most resemblance to Celebes. We have already seen

that the fauna of Borneo is essentially the same as that of Southern Asia,

and that it is excessively rich in all the Malayan types of {454} mammalia

and birds. Java and Bali closely resemble Borneo in general character,

though somewhat less rich and with several peculiar forms; while the

Philippine Islands, though very much poorer, and with a greater amount of

speciality, yet exhibit essentially the same character. These islands,

taken as a whole, may be described as having a fauna almost identical with

that of Southern Asia; for no family of mammalia is found in the one which

is absent from the other, and the same may be said, with very few and

unimportant exceptions, of the birds; while hundreds of genera and of

species are common to both.

In the islands east and south of Celebes--the Moluccas, New Guinea, and the

Timor group from Lombok eastward--we find, on the other hand, the most

wonderful contrast in the forms of life. Of twenty-seven families of

terrestrial mammals found in the great Malay islands, all have disappeared

but four, and of these it is doubtful whether two have not been introduced

by man. We also find here four families of Marsupials, all totally unknown

in the western islands. Even birds, though usually more widely spread, show

a corresponding difference, about eleven Malayan families being quite

unknown east of Celebes, where six new families make their appearance which

are equally unknown to the westward.[115]

We have here a radical difference between two sets of islands not very far

removed from each other, the one set belonging zoologically to Asia, the

other to Australia. The Asiatic or Malayan group is found to be bounded

strictly by the eastward limits of the great bank (for the most part less

than fifty fathoms below the surface) which {455} stretches out from the

Siamese and Malayan peninsula as far as Java, Sumatra, Borneo, and the

Philippines. To the east another bank unites New Guinea and the Papuan

Islands as far as Aru, Mysol, and Waigiou, with Australia; while the

Moluccas and Timor groups are surrounded by much deeper water, which forms,

in the Banda and Celebes Seas and perhaps in other parts of this area,

great basins of enormous depths (2,000 to 3,000 fathoms or even more)

enclosed by tracts under a thousand fathoms, which separate the basins from

each other and from the adjacent Pacific and Indian Oceans (see map). This

peculiar formation of the sea-bottom probably indicates that this area has

been the seat of great local upheavals and subsidences; and it is quite in

accordance with this view that we find the Moluccas, while closely agreeing

with New Guinea in their forms of life, yet strikingly deficient in many

important groups, and exhibiting an altogether poverty-stricken appearance

as regards the higher animals. It is a suggestive fact that the Philippine

Islands bear an exactly parallel relation to Borneo, being equally

deficient in many of the higher groups; and here too, in the Sooloo Sea, we

find a similar enclosed basin of great depth. Hence we may in both cases

connect, on the one hand, the extensive area of land-surface and of

adjacent shallow sea with a long period of stability and a consequent rich

development of the forms of life; and, on the other hand, a highly broken

land-surface with the adjacent seas of great but very unequal depths, with

a period of disturbance, probably involving extensive submersions of the

land, resulting in a scanty and fragmentary vertebrate fauna.

\_Zoology of Celebes.\_--The zoology of Celebes differs so remarkably from

that of both the great divisions of the Archipelago above indicated, that

it is very difficult to decide in which to place it. It possesses only

about sixteen species of terrestrial mammalia, so that it is at once

distinguished from Borneo and Java by its extreme poverty in this class. Of

this small number four belong to the Moluccan and Australian fauna--there

being two marsupials of the genus Cuscus, and two forest rats said to be

allied to Australian types. {456}

The remaining twelve species are, generally speaking, of Malayan or Asiatic

types, but some of them are so peculiar that they have no near allies in

any part of the world; while the rest are of the ordinary Malay type or

even identical with Malayan species, and some of these may be recent

introductions through human agency. These twelve species of Asiatic type

will be now enumerated. They consist of five peculiar squirrels--a group

unknown farther east; a peculiar species of wild pig; a deer so closely

allied to the \_Cervus hippelaphus\_ of Borneo that it may well have been

introduced by man both here and in the Moluccas; a civet, \_Viverra

tangalunga\_, common in all the Malay Islands, and also perhaps introduced;

the curious Malayan tarsier (\_Tarsius spectrum\_) said to be only found in a

small island off the coast;--and besides these, three remarkable animals,

all of large size and all quite unlike anything found in the Malay Islands

or even in Asia. These are a black and almost tailless baboon-like ape

(\_Cynopithecus nigrescens\_); an antelopean buffalo (\_Anoa depressicornis\_),

and the strange babirusa (\_Babirusa alfurus\_).

None of these three animals last mentioned has any close allies elsewhere,

and their presence in Celebes may be considered the crucial fact which must

give us the clue to the past history of the island. Let us then see what

they teach us. The ape is apparently somewhat intermediate between the

great baboons of Africa and the short-tailed macaques of Asia, but its

cranium shows a nearer approach to the former group, in its flat projecting

muzzle, large superciliary crests, and maxillary ridges. The anoa, though

anatomically allied to the buffaloes, externally more resembles the bovine

antelopes of Africa; while the babirusa is altogether unlike any other

living member of the swine family, the canines of the upper jaws growing

directly upwards like horns, forming a spiral curve over the eyes, instead

of downwards, as in all other mammalia. An approach to this peculiarity is

made by the African wart-hogs, in which the upper tusk grows out laterally

and then curves up; but these animals are not otherwise closely allied to

the babirusa. {457}

\_Probable Derivation of the Mammals of Celebes.\_--It is clear that we have

here a group of extremely peculiar, and, in all probability, very ancient

forms, which have been preserved to us by isolation in Celebes, just as the

monotremes and marsupials have been preserved in Australia, and so many of

the lemurs and Insectivora in Madagascar. And this compels us to look upon

the existing island as a fragment of some ancient land, once perhaps

forming part of the great northern continent, but separated from it far

earlier than Borneo, Sumatra, and Java. The exceeding scantiness of the

mammalian fauna, however, remains to be accounted for. We have seen that

Formosa, a much smaller island, contains more than twice as many species;

and we may be sure that at the time when such animals as apes and buffaloes

existed, the Asiatic continent swarmed with varied forms of mammals to

quite as great an extent as Borneo does now. If the portion of separated

land had been anything like as large as Celebes now is, it would certainly

have preserved a far more abundant and varied fauna. To explain the facts

we have the choice of two theories:--either that the original island has

since its separation been greatly reduced by submersion, so as to lead to

the extinction of most of the higher land animals; or, that it originally

formed part of an independent land stretching eastward, and was only united

with the Asiatic continent for a short period, or perhaps even never united

at all, but so connected by intervening islands separated by narrow straits

that a few mammals might find their way across. The latter supposition

appears best to explain the facts. The three animals in question are such

as might readily pass over narrow straits from island to island; and we are

thus better enabled to understand the complete absence of the arboreal

monkeys, of the Insectivora, and of the very numerous and varied Carnivora

and Rodents of Borneo, all of which except the squirrels are entirely

unrepresented in Celebes by any peculiar and ancient forms.

The question at issue can only be finally determined by geological

investigations. If Celebes has once formed part of Asia, and participated

in its rich mammalian fauna, which has been since destroyed by submergence,

then some {458} remains of this fauna must certainly be preserved in caves

or late Tertiary deposits, and proofs of the submergence itself will be

found when sought for. If, on the other hand, the existing animals fairly

represent those which have ever reached the island, then no such remains

will be discovered, and there need be no evidence of any great and

extensive subsidence in late Tertiary times.

\_Birds of Celebes.\_--Having thus clearly placed before us the problem

presented by the mammalian fauna of Celebes, we may proceed to see what

additional evidence is afforded by the birds and any other groups of which

we have sufficient information. About 164 species of true land-birds are

now known to inhabit the island of Celebes itself. Considerably more than

half of these (ninety-four species) are peculiar to it; twenty-nine are

found also in Borneo and the other Malay Islands, to which they specially

belong; while sixteen are common to the Moluccas or other islands of the

Australian region; the remainder being species of wide range and not

characteristic of either division of the Archipelago. We have here a large

preponderance of western over eastern species of birds inhabiting Celebes,

though not to quite so great an extent as in the mammalia; and the

inference to be drawn from this fact is, simply, that more birds have

migrated from Borneo than from the Moluccas--which is exactly what we might

expect both from the greater extent of the coast of Borneo opposite that of

Celebes, and also from the much greater richness in species of the Bornean

than the Moluccan bird-fauna.

It is, however, to the relations of the peculiar species of Celebesian

birds that we must turn, in order to ascertain the origin of the fauna in

past times; and we must look to the source of the generic types which they

represent to give us this information. The ninety-four peculiar species

above noted belong to about sixty-six genera, of which about twenty-three

are common to the whole Archipelago, and have therefore little

significance. Of the remainder, twelve are altogether peculiar to Celebes;

twenty-one are Malayan, but not Moluccan or Australian; while ten are

Moluccan or Australian, but not Malayan. This {459} proportion does not

differ much from that afforded by the non-peculiar species; and it teaches

us that, for a considerable period, Celebes has been receiving immigrants

from all sides, many of which have had time to become modified into

distinct representative species. These evidently belong to the period

during which Borneo on the one side, and the Moluccas on the other, have

occupied very much the same relative position as now. There remain the

twelve peculiar Celebesian genera, to which we must look for some further

clue as to the origin of the older portion of the fauna; and as these are

especially interesting we must examine them somewhat closely.

\_Bird-types Peculiar to Celebes.\_--First we have Artamides, one of the

CampephaginÃ¦ or caterpillar-shrikes--a not very well-marked genus, and

which may have been derived, either from the Malayan or the Moluccan side

of the Archipelago. Two peculiar genera of kingfishers--Monachalcyon and

Cittura--seem allied, the former to the widespread Todiramphus and to the

Caridonax of Lombok, the latter to the Australian Melidora. Another

kingfisher, Ceycopsis, combines the characters of the Malayan Ceyx and the

African Ispidina, and thus forms an example of an ancient generalised form

analogous to what occurs among the mammalia. Streptocitta is a peculiar

form allied to the magpies; while Basilornis (found also in Ceram), Enodes,

and Scissirostrum, are very peculiar starlings, the latter altogether

unlike any other bird, and perhaps forming a distinct sub-family. Meropogon

is a peculiar bee-eater, allied to the Malayan Nyctiornis; Rhamphococyx is

a modification of PhÃ¦nicophaes, a Malayan genus of cuckoos; Prioniturus

(found also in the Philippines) is a genus of parrots distinguished by

raquet-formed tail feathers, altogether unique in the order; while

Megacephalon is a remarkable and very isolated form of the Australian

MegapodiidÃ¦, or mound-builders.

Omitting those whose affinity may be pretty clearly traced to groups still

inhabiting the islands of the western or the eastern half of the

Archipelago, we find four birds which have no near allies at all, but

appear to be either ancestral forms, or extreme modifications, of Asiatic

or {460} African birds--Basilornis, Enodes, Scissirostrum, Ceycopsis. These

may fairly be associated with the baboon-ape, anoa, and babirusa, as

indicating extreme antiquity and some communication with the Asiatic

continent at a period when the forms of life and their geographical

distribution differed considerably from what they are at the present time.

But here again we meet with exactly the same difficulty as in the mammalia,

in the comparative poverty of the types of birds now inhabiting Celebes.

Although the preponderance of affinity, especially in the case of its more

ancient and peculiar forms, is undoubtedly with Asia rather than with

Australia; yet, still more decidedly than in the case of the mammalia, are

we forbidden to suppose that it ever formed a part of the old Asiatic

continent, on account of the \_total\_ absence of so many important and

extensive groups of Asiatic birds. It is not single species or even genera,

but whole families that are thus absent, and among them families which are

pre-eminently characteristic of all tropical Asia. Such are the TimaliidÃ¦,

or babblers, of which there are twelve genera in Borneo, and nearly thirty

genera in the Oriental Region, but of which one species only, hardly

distinguishable from a Malayan form, inhabits Celebes; the PhyllornithidÃ¦,

or green bulbuls, and the PycnonotidÃ¦, or bulbuls, both absolutely

ubiquitous in tropical Asia and Malaya, but unknown in Celebes; the

EurylÃ¦midÃ¦, or gapers, found everywhere in the great Malay Islands; the

MegalÃ¦midÃ¦, or barbets; the TrogonidÃ¦, or trogons; and the PhasianidÃ¦, or

pheasants, all pre-eminently Asiatic and Malayan but all absent from

Celebes, with the exception of the common jungle-fowl, which, owing to the

passion of Malays for cock-fighting, may have been introduced. To these

important \_families\_ may be added Asiatic and Malayan \_genera\_ by the

score; but, confining ourselves to these seven ubiquitous families, we must

ask,--Is it possible, that, at the period when the ancestors of the

peculiar Celebes mammals entered the island, and when the forms of life,

though distinct, could not have been quite unlike those now living, it

could have actually formed a part of the continent without {461} possessing

representatives of the greater part of these extensive and important

families of birds? To get rid altogether of such varied and dominant types

of bird-life by any subsequent process of submersion is more difficult than

to exterminate mammalia; and we are therefore again driven to our former

conclusion--that the present land of Celebes has never (in Tertiary times)

been united to the Asiatic continent, but has received its population of

Asiatic forms by migration across narrow straits and intervening islands.

Taking into consideration the amount of affinity on the one hand, and the

isolation on the other, of the Celebesian fauna, we may probably place the

period of this earlier migration in the early part of the latter half of

the Tertiary period, that is, in middle or late Miocene times.

\_Celebes not Strictly a Continental Island.\_--A study of the mammalian and

of the bird-fauna of Celebes thus leads us in both cases to the same

conclusion, and forbids us to rank it as a strictly continental island on

the Asiatic side. But facts of a very similar character are equally opposed

to the idea of a former land-connection with Australia or New Guinea, or

even with the Moluccas. The numerous marsupials of those countries are all

wanting in Celebes, except the phalangers of the genus Cuscus, and these

arboreal creatures are very liable to be carried across narrow seas on

trees uprooted by earthquakes or floods. The terrestrial cassowaries are

equally absent; and thus we can account for the presence of all the

Moluccan or Australian types actually found in Celebes without supposing

any land-connection on this side during the Tertiary period. The presence

of the Celebes ape in the island of Batchian, and of the babirusa in Bouru,

can be sufficiently explained by a somewhat closer approximation of the

respective lands, or by a few intervening islands which have since

disappeared, or it may even be due to human agency.

If the explanation now given of the peculiar features presented by the

fauna of Celebes be the correct one, we are fully justified in classing it

as an "anomalous island," since it possesses a small but very remarkable

mammalian fauna, without ever having been directly united with any {462}

continent or extensive land; and, both by what it has and what it wants,

occupies such an exactly intermediate position between the Oriental and

Australian regions that it will perhaps ever remain a mere matter of

opinion with which it should properly be associated. Forming, as it does,

the western limit of such typical Australian groups as the Marsupials among

mammalia, and the TrichoglossidÃ¦ and MeliphagidÃ¦ among birds, and being so

strikingly deficient in all the more characteristic Oriental families and

genera of both classes, I have always placed it in the Australian Region;

but it may perhaps with equal propriety be left out of both till a further

knowledge of its geology enables us to determine its early history with

more precision.

\_Peculiarities of the Insects of Celebes.\_--The only other class of animals

in Celebes, of which we have a tolerable knowledge, is that of insects,

among which we meet with peculiarities of a very remarkable kind, and such

as are found in no other island on the globe. Having already given a full

account of some of these peculiarities in a paper read before the Linnean

Society--republished in my \_Contributions to the Theory of Natural

Selection\_,--while others have been discussed in my \_Geographical

Distribution of Animals\_ (Vol. I. p. 434)--I will only here briefly refer

to them in order to see whether they accord with, or receive any

explanation from, the somewhat novel view of the past history of the island

here advanced.

The general distribution of the two best known groups of insects--the

butterflies and the beetles--agrees very closely with that of the birds and

mammalia, inasmuch as Celebes forms the eastern limit of a number of

Asiatic and Malayan genera, and at the same time the western limit of

several Moluccan and Australian genera, the former perhaps preponderating

as in the higher animals.

\_Himalayan Types of Birds and Butterflies in Celebes.\_--A curious fact of

distribution exhibited both among butterflies and birds, is the occurrence

in Celebes of species and genera unknown to the adjacent islands, but only

found again when we reach the Himalayan mountains or the Indian Peninsula.

Among birds we have a small yellow {463} flycatcher (\_Myialestes

helianthea\_), a flower-pecker (\_Pachyglossa aureolimbata\_), a finch (\_Munia

brunneiceps\_), and a roller (\_Coracias temminckii\_), all closely allied to

Indian (not Malayan) species,--all the genera, except Munia, being, in

fact, unknown in any Malay island. An exactly parallel case is that of a

butterfly of the genus Dichorrhagia, which has a very close ally in the

Himalayas, but nothing like it in any intervening country. These facts call

to mind the similar case of Formosa, where some of its birds and mammals

occurred again, under identical or closely allied forms, in the Himalayas;

and in both instances they can only be explained by going back to a period

when the distribution of these forms was very different from what it is

now.

\_Peculiarities of Shape and Colour in Celebesian Butterflies.\_--Even more

remarkable are the peculiarities of shape and colour in a number of

Celebesian butterflies of different genera. These are found to vary all in

the same manner, indicating some general cause of variation able to act

upon totally distinct groups, and produce upon them all a common result.

Nearly thirty species of butterflies, belonging to three different

families, have a common modification in the shape of their wings, by which

they can be distinguished at a glance from their allies in any other island

or country whatever; and all these are larger than the representative forms

inhabiting most of the adjacent islands.[116] No such remarkable local

modification as this is known to occur in any other part of the globe; and

whatever may have been its cause, that cause must certainly have been long

in action, and have been confined to a limited area. We have here,

therefore, another argument in favour of the long-continued isolation of

Celebes from all the surrounding islands and continents--a hypothesis which

we have seen to afford the best, if not the only, explanation of its

peculiar vertebrate fauna.

\_Concluding Remarks.\_--If the view here given of the origin of the

remarkable Celebesian fauna is correct, we have in this island a fragment

of the great eastern {464} continent which has preserved to us, perhaps

from Miocene times, some remnants of its ancient animal forms. There is no

other example on the globe of an island so closely surrounded by other

islands on every side, yet preserving such a marked individuality in its

forms of life; while, as regards the special features which characterise

its insects, it is, so far as yet known, absolutely unique. Unfortunately

very little is known of the botany of Celebes, but it seems probable that

its plants will to some extent partake of the speciality which so markedly

distinguishes its animals; and there is here a rich field for any botanist

who is able to penetrate to the forest-clad mountains of its interior.

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APPENDIX TO CHAPTER XX

The following list of the Land Birds of Celebes and the adjacent islands

which partake of its zoological peculiarities, in which are incorporated

all the species discovered up to 1890, has been drawn up from the following

sources:--

1. A List of the Birds known to inhabit the Island of Celebes, By

Arthur, Viscount Walden, F.R.S. (Trans. Zool. Soc. 1872. Vol. viii. pt.

ii.)

2. Intorno al Genere Hermotimia. (Rchb.) Nota di Tommaso Salvadori.

(Atti della Reale Accademia delle Scienze di Torino. Vol x. 1874.)

3. Intorno a due Collezioni di Ucelli di Celebes--Note di Tommaso

Salvadori. (Annali del Mus. Civ. di St. Nat. di Genova. Vol. vii.

1875.)

4. BeitrÃ¤ge zur Ornithologie von Celebes und Sangir. Von Dr. Friedrich

BrÃ¼ggemann. Bremen, 1876.

5. Intorno a due piccole Collezioni di Ucelli di Isole Sanghir e di

Tifore. Nota di Tommaso Salvadori. (Annali del Mus. Civ. di St. Nat. di

Genova. Vol. ix. 1876-77.)

6. Intorno alle Specie di Nettarinie delle Molucche e del Gruppo di

Celebes. Note di Tommaso Salvadori. (Atti della Reale Accad. delle

Scienze di Torino. Vol. xii. 1877.)

7. Descrizione di tre Nuove Specie di Ucelli, e note intorno ad altre

poco conosciute delle Isole Sanghir. Per Tommaso Salvadori. (L. c. Vol.

xiii. 1878.)

8. Field Notes on the Birds of Celebes. By A. B. Meyer, M.D., &c.

(Ibis, 1879.)

9. On the Collection of Birds made by Dr. Meyer during his Expedition

to New Guinea and some neighbouring Islands. By R. Boulder Sharpe.

(Mitth. d. kgl. Zool. Mus. Dresden, 1878. Heft 3.) New species from the

Sula and Sanghir Islands are described.

10. List of Birds from the Sula Islands (East of Celebes) with

Descriptions of the New Species. By Alfred Russel Wallace, F.Z.S.

(\_Proc. Zool. Soc.\_ 1862, p. 333.)

11. The Zoological Record, and "The Ibis" to 1890.

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LIST OF LAND BIRDS OF CELEBES

\_N.B.--The Species marked with an \* are not included in Viscount Walden's

list. For these only, an authority is usually given.\_

--------------------------------+-------+-------+-------+-------------

|Celebes| Sula |Sanghir| Range and

| | Is. | Is. | Remarks

--------------------------------+-------+-------+-------+-------------

TURDIDÃ. | | | |

1. Geocichla erythronota | X | | |

2. Monticola solitaria | X | | X |Phil., China,

| | | | Japan

| | | |

SYLVIIDÃ. | | | |

3. Cisticola cursitans | X | | |Assam

4 ,, grayi | X | | |

5. Acrocephalus orientalis | X | | |China, Japan

\*6. ,, insularis | -- | -- | X |Moluccas

| | |(Salv.)|

7. Pratincola caprata | X | | |Asia, Java,

| | | | Timor

\*8. Gerygone flaveola (Cab.) | X | | |(Near G.

|(Meyer)| | |\_sulphurea\_,

| | | |Timor)

| | | |

TIMALIIDÃ. | | | |

9. Trichostoma celebense | X | | |

| | | |

PYCNONOTIDÃ. | | | |

\*10. Criniger longirostris | | | |

(Wall.) | | X | |Oriental

| | | | genus (near

| | | | Bouru sp.)

11. ,, aureus (Wald.) | X | | |

| | | |

ORIOLIDÃ. | | | |

12. Oriolus celebensis | X | | |(Var of O.

| | | | \_coronatus\_,

| | | | Java)

13. ,, formosus (Cab.) | -- | -- | X |(Var. of

| | |(Brugg.) Philipp.

| | | | sp.)

14. ,, frontalis (Wall.) | -- | X | |

| | | |

CAMPEPHAGIDÃ. | | | |

15. Graucalus atriceps | X | | |Ceram, Flores

16. ,, leucopygius | X | | |

17. ,, temminckii | X | X | |

18. Campephaga morio | X | | |

\*19. ,, melanotis | -- | X | |Moluccas

\*20. ,, salvadorii | |(Wall.)| |

(Sharpe) | -- | -- | X |

21. Lalage leucopygialis | X | | |

\*22. ,, dominica | X | -- | -- |Java

|(Meyer)| | |

23. Artamides bicolor | X | | |

\*24. ,, schistaceus | | | |

(Sharpe) | -- | X | |

| | | |

DICRURIDÃ. | | | |

25. Dicrurus leucops | X | | |

\*26. ,, axillaris (Salv.) | -- | -- | X |

\*27. ,, pectoralis (Wall.) | | X | |

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| | | |

MUSCICAPIDÃ. | | | |

28. Cyornis rufigula | X | | |

29. ,, banyumas | X | | |Java and Borneo

30. Myialestes helianthea | X | | |(Indian ally)

31. Hypothymis puella | X | X | |

32. ,, menadensis? | X | | |

\*33. Monarcha commutata | | | |

(Brugg.) | X | | |

\*34. ,, cinerascens | -- | X | |Moluccas

| |(Wall.)| |

PACHYCEPHALIDÃ. | | | |

35. Hylocharis sulfuriventra | X | | |

\*36. Pachycephala lineolata | | | |

(Wall.) | -- | X | -- |Bouru

\*37. Pachycephala rufescens | | | |

(Wall.) | -- | X | -- |Bouru

\*38. Pachycephala clio (Wall.) | -- | X | -- |Bouru

| | | |

LANIIDÃ. | | | |

\*39. Lanius magnirostris (Meyer)| X | -- | -- |Java

| | | |

CORVIDÃ. | | | |

40. Corvus enca | X | X var.| |Java

\*41. ,, annectens (Brugg.) | X | | |

42. ,,(Gazzola) typica | X | | |

43. Streptocitta caledonica | X | | |

44. ,, torquata | X | | |

\*45(Charitornis) albertiÃ¦(Schl.)| -- | X | |

| | | |

MELIPHAGIDÃ. | | | |

46. Myzomela chloroptera | X | | |(Nearest \_M.

| | | |sanguinolenta\_

| | | |of Australia)

NECTARINIIDÃ. | | | |

47. Anthreptes celebensis | | | |

(Shelley) | X | X | X |Siam, Malaya

48. Chalcostethia porphyolÃ¦ma | X | | |

\*49. ,, auriceps | -- | X | -- |Ternate

| |(Wall.)| |

\*50. ,, sangirensis | -- | -- | X |

(Meyer) | | | |

51. Cyrtostomus frenatus | X | X | -- |Moluccas and N.

| | | | Guinea

52. Nectarophila grayi | X | | |

53. Ãthopyga flavostriata | X | | |(An Oriental

| | | | genus)

\*54. ,, beccarii (Salv.) | X | | |

\*55. ,, duyvenbodei (Schl.)| -- | -- | X |

| | | |

DICÃIDÃ. | | | |

56. Zosterops intermedia | X | | |Lombock

57. ,, atrifrons | X | | |

58. DicÃ¦um celebicum | X | X | |

\*59. ,, sanghirense (Salv.) | -- | -- | X |

\*60. ,, nehrkorni (Blas.) | X | | |

61. Pachyglossa aureolimbata | X | -- | X |

| | | |

HIRUNDINIDÃ. | | | |

62. Hirundo gutturalis | X | | X |Indian region

63. ,, javanica | X | X | |Indo-Malaya

| | | |

PLOCEIDÃ. | | | |

64. Munia oryzivora | X | | |Java

65. ,, nisoria | X | | |Java

66. ,, molucca | X | | |Moluccas

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67. ,, brunneiceps | X | | |(Near \_M.

| | | |rubronigra\_,

| | | |India)

\*68. ,, jagori | X | | |Philippines

|(Meyer)| | |

STURNIDÃ. | | | |

69. Basilornis celebensis | X | | |

70. Acridotheres cinereus | X | | |

71. Sturnia pyrrhogenys | X | | |Malaya

72. Calornis neglecta | X | X | X var.|

\*73. ,, metallica | X | X | |Moluccas

|(Brugg.)(Wall.)| |

74. Enodes crythrophrys | X | | |

75. Scissirostrum pagei | X | | |

| | | |

ARTAMIDÃ. | | | |

76. Artamus monachus | X | X | |

77. ,, leucorhynchus | X | | |Malay Archipel.

| | | |

MOTACILLIDÃ. | | | |

78. Corydalla gustavi | X | | |

79. Budytes viridis | X | | |Java, Moluccas

\*80. Calobates melanope | | | |

(= Motac. sulfurea, Brugg.) | X | | |China, Phillipp.

| | | |

PITTIDÃ. | | | |

81. Pitta forsteni | X | | |

\*82. ,, sanghirana (Schl.) | | | X |

83. ,, celebensis | X | | |

\*84. ,, palliceps (Brugg.) | | | X |

\*85. ,, coeruleitorques (Salv.) | | X |

\*86. ,, irena (= crassirostris) | X | |Timor, Ternate?

| |(Wall.)| |

PICIDÃ. | | | |

87. Alophonerpes fulvus | X | | |

\*88. ,, wallacei | | | |

89. Yungipicus temminckii | X | | |

| | | |

CUCULIDÃ. | | | |

90. Rhamphococcyx calorhynchus | X | | |

91. Pyrrhocentor celebensis | X | | |

92. Centropus affinis | X | | |Java

93. ,, javanensis | X | | |Java, Borneo

94. Cuculus canorus | X | | |

95. Cacomantes lanceolatus | X | | |Java

96. ,, sepulchralis | X | | |

97. Hierococcyx crassirostris | X | | |

98. Eudynamis melanorhyncha | X | | |

\*99. ,, facialis (Wall.) | | X | |

\*100. ,, orientalis | | | X |Moluccas?

| | |(Brugg.)

101. Scythrops novÃ¦hollandiÃ¦ | X | | |Moluccas, &c.

| | | |

CORACIIDÃ. | | | |

102. Coracias temminckii | X | | |

103. Eurystomus orientalis | X | X | X |Asia

| | | |

MEROPIDÃ. | | | |

104. Meropogon forsteni | X | | |

105. Merops philippinus | X | | |Oriental region

106. ,, ornatus | X | X | |Java, Australia

| | | |

ALCEDINIDÃ. | | | |

107. Alcedo moluccensis | X | | X |Moluccas

108. ,, asiatica | X | | |Indo-Malaya

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109. Pelargopsis melanorhyncha | X | X | |

\*110. Ceyx wallacei (Sharpe) | | X | |(Allied to Mol.

| | | | sp.)

111. Ceycopsis fallax | X | | |

112. Halcyon chloris | X | X | X |All Archipel.

113. ,, sancta | X | X | |All Archipel.

114. ,, forsteni | X | | |

115. ,, rufa | X | X | |

116. Monachalcyon princeps | X | | |

\*117. ,, cyanocephala (Brugg.) | X | | |

118. Cittura cyanotis | X | | |

\*119. ,, sanghirensis (Schl.)| | | X |

| | | |

BUCEROTIDÃ. | | | |

120. Hydrocissa exarata | X | | |

121. Cranorhinus cassidix | X | | |

| | | |

CAPRIMULGIDÃ. | | | |

122. Caprimulgus affinis | X | | |

123. ,, sp. | X | | |

124. Lyncornis macropterus. | X | | |

| | | |

CYPSELIDÃ. | | | |

125. Dendrochelidon wallacei | X | X | |

126. Collocalia esculenta | X | | |Mol. to Arn Is.

127. ,, fuciphaga | X | | |India, Java

128. ChÃ¦tura gigantea | X | | |India, Java

| | | |

PSITTACI. | | | |

129. Cacatua sulphurea | X | | |Lombock, Flores

130. Prioniturus platurus | X | | |

131. ,, flavicans | X | | |

\*132. Platycercus dorsalis, var.| | X | |N. Guinea?

| |(Wall.)| |

133. Tanygnathus mulleri | X | X | |

\*134. ,, megalorhynchus | X | | X |Moluccas. An

| | | |island near

| | | |Menado (Meyer)

\*135. ,, luzoniensis | | | X |

| | |(Brugg.)

136. Loriculus stigmatus | X | | |

\*137. ,, quadricolor (Wald.)| X | | |Togian Is., Gulf

| | | |of Tomini

138. ,, sclateri | ? | X | |

139. ,, exilis | X | | |

\*140. ,, catamene (Schl.) | | | X |

141. Trichoglossus ornatus | X | | |

\*142. ,, flavoviridis (Wall.)| | X | |

143. ,, meyeri | X | | |

\*144. Eos histrio = E. coccinea | | | X |

| | | |

COLUMBÃ. | | | |

145. Treron vernans | X | | |Malacca, Java,

| | | |Philipp.

146. ,, griseicauda | X | X | X var.|

| | |Sanghir-

| | | ensis |

147. Ptilopus formosus | X | | |

148. ,, melanocephalus | X | X | X var.|Java, Lombock

| | |Xantho-|

| | | rrhoa,|

| | |Salv. |

149. ,, gularis | X | | |

\*150. ,, fischeri (Brugg.)| X | | |

151. Carpophaga paulina | X | X | |

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\*152. ,, pulchella | X | | |Togian Is.

(Wald.) | | | |(\_Ann. and

| | | |Mag. Nat. Hst.\_,

| | | |1874.)

153. ,, concinna | | | X |KÃ© Goram

| | |(Salv.)|

154. ,, rosacea | X | | |Gilolo, Timor

\*155. ,, pÃ¦cilorrhoa (Brugg) | X | | |

156. ,, luctuosa | X | X | |

\*157. ,, bicolor | X | | X |New Guin.,

|(Meyer)| | |Moluccas

158. ,, radiata | X | | X |

159. ,, forsteni | X | | |

160. Macropygia albicapilla | X | X | |

161. ,, macassariensis | X | | |

\*162. ,, sanghirensis (Salv.) | | | X |

163. Turacoena menadensis | X | X | |

\*164. ReinwardtÃ¦nas reinwardti |X Meyer| | |Moluccas & New

| | | |Guin.

165. Turtur tigrina | X | | |Malaya, Moluccas

166. Chalcophaps stephani | X | | |New Guinea

167. ,, indica | X | X var.| X |India and

| | | |Archipel.

168. PhlogÃ¦nas tristigmata | X | | |

169. Geopelia striata | X | | |China, Java,

| | | |Lombock

170. CalÃ¦nas nicobarica | X | | |Malacca and New

| | | |Guinea

| | | |

GALLINÃ. | | | |

171. Gallus bankiva | X | | |Java, Timor

172. Coturnix minima | X | | |(Var. of \_C.

| | | |Chinensis\_)

173. Turnix rufilatus | X | | |

\*174. ,, beccarii (Salv.) | X | | |

175. Megapodius gilberti | X | | |

176. Megacephalon malleo | X | | X |

| | | |

ACCIPITRES. | | | |

177. Circus assimilis | X | | |Australia

178. Astur griseiceps | X | | |

\*179. ,, tenuirostris (Brugg.) X | | |

180. ,, rhodogastra | X | | |

181. ,, trinotata | X | | |

182. Accipiter sulaensis (Schl.) X | | |

183. ,, soloensis | X | | |Malacca & New

| | | |Guin.

184. Neopus malayensis | X | | |Nepaul, Sum.,

| | | |Java, Moluccas

185. Spizaetus lanceolatus | X | X | |

186. Haliactus leucogaster | X | | |Oriental region

187. Spilornis rufipectus | X | X | |

188. Butastur liventer | X | | |Java, Timor

189. ,, indicus | X | | X |India, Java

190. Haliastur leucosternus | X | | |Moluccas, New

| | | |Guin.

191. Milvus affinis | X | | |Australia

192. Elanus hypoleucus | X | | |? Java, Borneo

193. Pernis ptilorhyncha (var. | | | |

celebensis) | X | | |(Var. Java, &c.)

194. Baza erythrothorax | X | X | |

195. Falco severus | X | | |All Archipel.

196. Cerchneis moluccensis | X | | |Java, Moluccas

197. Polioaetus humilis | X | | |India, Malaya

| | | |

STRIGIDÃ. | | | |

198. Athene punctulata | X | | |

199. ,, ochracea | X | | |

200. Scops magicus | X | | |Amboyna, &c.?

201. ,, menadensis | X | | |Flores,

| | | |Madagascar

202. Ninox japonicus | X | | |China, Japan

\*203. ,, scutulata | | | X |Malacca

| | |(Salv.)|

204. Strix rosenbergi | X | | |

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CHAPTER XXI

ANOMALOUS ISLANDS: NEW ZEALAND

Position and Physical Features of New Zealand--Zoological Character of

New Zealand--Mammalia--Wingless Birds Living and Extinct--Recent

Existence of the Moa--Past Changes of New Zealand deduced from its

Wingless Birds--Birds and Reptiles of New Zealand--Conclusions from the

Peculiarities of the New Zealand Fauna.

The fauna of New Zealand has been so recently described, and its bearing on

the past history of the islands so fully discussed in my large work already

referred to, that it would not be necessary to introduce the subject again,

were it not that we now approach it from a somewhat different point of

view, and with some important fresh material, which will enable us to

arrive at more definite conclusions as to the nature and origin of this

remarkable fauna and flora. The present work is, besides, addressed to a

wider class of readers than my former volumes, and it would be manifestly

incomplete if all reference to one of the most remarkable and interesting

of insular faunas was omitted.

The two great islands which mainly constitute New Zealand are together

about as large as the kingdom of Italy. They stretch over thirteen degrees

of latitude in the warmer portion of the south-temperate zone, their

extreme points corresponding to the latitudes of Vienna and Cyprus. Their

climate throughout is mild and {472} equable, their vegetation is

luxuriant, and deserts or uninhabitable regions are as completely unknown

as in our own islands.

The geological structure of these islands has a decidedly continental

character. Ancient sedimentary rocks, granite, and modern volcanic

formations abound; gold, silver, copper, tin, iron, and coal are plentiful;

and there are also some considerable deposits of early or late Tertiary

age. The Secondary rocks alone are very scantily developed, and such

fragments as exist are chiefly of Cretaceous age, often not clearly

separated from the succeeding Eocene beds.

[Illustration: MAP SHOWING DEPTHS OF SEA AROUND AUSTRALIA AND NEW ZEALAND.]

The light tint indicates a depth of less than 1,000 fathoms.

The dark tint ,, ,, more than 1,000 fathoms.

The position of New Zealand, in the great Southern Ocean, about 1,200 miles

distant from the Australian {473} continent, is very isolated. It is

surrounded by a moderately deep ocean; but the form of the sea-bottom is

peculiar, and may help us in the solution of some of the anomalies

presented by its living productions. The line of 200 fathoms encloses the

two islands and extends their area considerably; but the 1,000-fathom line,

which indicates the land-area that would be produced if the sea-bottom were

elevated 6,000 feet, has a very remarkable conformation, extending in a

broad mass westward and northward, then sending out a great arm reaching to

beyond Lord Howe's Island. Norfolk Island is situated on a moderate-sized

bank, while two others, much more extensive, to the north-west approach the

great barrier reef, which here carries the 1,000-fathom line more than 300

miles from the coast. It is probable that a bank, less than 1,500 fathoms

below the surface, extends over this area, thus forming a connection with

tropical Australia and New Guinea. Temperate Australia, on the other hand,

is divided from New Zealand by an oceanic gulf about 700 miles wide and

between 2,000 and 3,000 fathoms deep. The 2,000-fathom line embraces all

the islands immediately round New Zealand as far as the Fijis to the north,

while a submarine plateau at a depth somewhere between one and two thousand

fathoms stretches southward to the Antarctic continent. Judging from these

indications, we should say that the most probable ancient connections of

New Zealand were with tropical Australia, New Caledonia, and the Fiji

Islands, and perhaps at a still more remote epoch, with the great Southern

continent by means of intervening lands and islands; and we shall find that

a land-connection or near approximation in these two directions, at remote

periods, will serve to explain many of the remarkable anomalies which these

islands present.

\_Zoological Character of New Zealand.\_--We see, then, that both

geologically and geographically New Zealand has more of the character of a

"continental" than of an "oceanic" island, yet its zoological

characteristics are such as almost to bring it within the latter

category--and it is this which gives it its anomalous character. It is

usually {474} considered to possess no indigenous mammalia; it has no

snakes, and only one frog; it possesses (living or quite recently extinct)

an extensive group of birds incapable of flight; and its productions

generally are wonderfully isolated, and seem to bear no predominant or

close relation to those of Australia or any other continent. These are the

characteristics of an oceanic island; and thus we find that the inferences

from its physical structure and those from its forms of life directly

contradict each other. Let us see how far a closer examination of the

latter will enable us to account for this apparent contradiction.

\_Mammalia of New Zealand.\_--The only undoubtedly indigenous mammalia appear

to be two species of bats, one of which (\_Scotophilus tuberculatus\_) is,

according to Mr. Dobson, identical with an Australian form, while the other

(\_Mystacina tuberculata\_) forms a very remarkable and isolated genus of

EmballonuridÃ¦, a family which extends throughout all the tropical regions

of the globe. The genus Mystacina was formerly considered to belong to the

American PhyllostomidÃ¦, but this has been shown to be an error.[117] The

poverty of New Zealand in bats is very remarkable when compared with our

own islands where there are at least twelve distinct species, though we

have a far less favourable climate.

Of the existence of truly indigenous land mammals in New Zealand there is

at present no positive evidence, but there is some reason to believe that

one if not two species may be found there. The Maoris say that before

Europeans came to their country a forest-rat abounded and was largely used

for food. They believe that their ancestors brought it with them when they

first came to the country; but it has now become almost, if not quite,

exterminated by the European brown rat. What this native animal was is

still somewhat doubtful. Several specimens have been caught at different

times which have been declared by the natives to be the true \_Kiore

Maori\_--as they term it, but these have usually proved on examination to be

either the European black rat or some of the native Australian rats which

now {475} often find their way on board ships. But within the last few

years many skulls of a rat have been obtained from the old Maori

cooking-places, and from a cave associated with moa bones; and Captain

Hutton, who has examined them, states that they belong to a true Mus, but

differ from the \_Mus rattus\_. This animal might have been on the islands

when the Maoris first arrived, and in that case would be truly indigenous;

while the Maori legend of their "ancestors" bringing the rat from their

Polynesian home may be altogether a myth invented to account for its

presence in the islands, because the only other land mammal which they

knew--the dog--was certainly so brought. The question can only be settled

by the discovery of remains of a rat in some deposit of an age decidedly

anterior to the first arrival of the Maori race in New Zealand.[118]

Much more interesting is the reported existence in the mountains of the

South Island of a small otter-like animal. Dr. Haast has seen its tracks,

resembling those of our European otter, at a height of 3,000 feet above the

sea in a region never before trodden by man; and the animal itself was seen

by two gentlemen near Lake Heron, about seventy miles due west of

Christchurch. It was described as being dark brown and the size of a large

rabbit. On being struck at with a whip, it uttered a shrill yelping sound

and disappeared in the water.[119] An animal seen so closely as to be

struck at with a whip could hardly have been mistaken for a dog--the only

other animal that it could possibly be supposed to have been, and a dog

would certainly not have "disappeared in the water." This account, as well

as the footsteps, point to an aquatic animal; and if it now frequents only

the high alpine lakes and streams, this might explain why it has never yet

been captured. Hochstetter also states that it has a native

name--Waitoteke--a striking evidence of its actual existence, while a

gentleman who lived many years in the district assures me that {476} it is

universally believed in by residents in that part of New Zealand. The

actual capture of this animal and the determination of its characters and

affinities could not fail to aid us greatly in our speculations as to the

nature and origin of the New Zealand fauna.[120]

\_Wingless Birds, Living and Extinct.\_--Almost equally valuable with

mammalia in affording indications of geographical changes are the wingless

birds for which New Zealand is so remarkable. These consist of four species

of Apteryx, called by the natives "kiwis,"--creatures which hardly look

like birds owing to the apparent absence (externally) of tail or wings and

the dense covering of hair-like feathers. They vary in size from that of a

small fowl up to that of a turkey, and have a long slightly curved bill,

somewhat resembling that of the snipe or ibis. Two species appear to be

confined to the South Island, and one to the North Island, but all are

becoming scarce, and they will no doubt gradually become extinct. These

birds are generally classed with the Struthiones or ostrich tribe, but they

form a distinct family, and in many respects differ greatly from all other

known birds.

But besides these, a number of other wingless birds, called "moas,"

inhabited New Zealand during the period of human occupation, and have only

recently become extinct. These were much larger birds than the kiwis, and

some of them were even larger than the ostrich, a specimen {477} of

\_Dinornis maximus\_ mounted in the British Museum in its natural attitude

being eleven feet high. They agreed, however, with the living Apteryx in

the character of the pelvis and some other parts of the skeleton, while in

their short bill and in some important structural features they resembled

the emu of Australia and the cassowaries of New Guinea.[121] No less than

eleven distinct species of these birds have now been discovered; and their

remains exist in such abundance--in recent fluviatile deposits, in old

native cooking places, and even scattered on the surface of the

ground--that complete skeletons of several of them have been put together,

illustrating various periods of growth from the chick up to the adult bird.

Feathers have also been found attached to portions of the skin, as well as

the stones swallowed by the birds to assist digestion, and eggs, some

containing portions of the embryo bird; so that everything confirms the

statements of the Maoris--that their ancestors found these birds in

abundance on the islands, that they hunted them for food, and that they

finally exterminated them only a short time before the arrival of

Europeans.[122] Bones of Apteryx are also found fossil, but apparently of

the same species as the living birds. {478} How far back in geological time

these creatures or their ancestral types lived in New Zealand we have as

yet no evidence to show. Some specimens have been found under a

considerable depth of fluviatile deposits which may be of Quaternary or

even of Pliocene age; but this evidently affords us no approximation to the

time required for the origin and development of such highly peculiar

insular forms.

\_Past Changes of New Zealand deduced from its Wingless Birds.\_--It has been

well observed by Captain Hutton, in his interesting paper already referred

to, that the occurrence of such a number of species of Struthious birds

living together in so small a country as New Zealand is altogether

unparalleled elsewhere on the globe. This is even more remarkable when we

consider that the species are not equally divided between the two islands,

for remains of no less than ten out of the eleven known species of Dinornis

have been found in a single swamp in the South Island, where also three of

the species of Apteryx occur. The New Zealand Struthiones, in fact, very

nearly equal in number those of all the rest of the world, and nowhere else

do more than three species occur in any one continent or island, while no

more than two ever occur in the same district. Thus, 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 cassowaries are known from

the islands north of Australia--one from Ceram, two from the Aru Islands,

one from Jobie, one from New Britain, and three from New Guinea--but of

these last one is confined to the northern and another to the southern part

of the island.

This law, of the distribution of allied species in separate areas--which is

found to apply more or less accurately to all classes of animals--is so

entirely opposed to the crowding together of no less that fifteen species

of wingless birds in the small area of New Zealand, that the idea is at

once suggested of great geographical changes. Captain Hutton points out

that if the islands from Ceram to New Britain {479} were to become joined

together, we should have a large number of species of cassowary (perhaps

several more than are yet discovered) in one land area. If now this land

were gradually to be submerged, leaving a central elevated region, the

different species would become crowded together in this portion just as the

moas and kiwis were in New Zealand. But we also require, at some remote

epoch, a more or less complete union of the islands now inhabited by the

separate species of cassowaries, in order that the common ancestral form

which afterwards became modified into these species, could have reached the

places where they are now found; and this gives us an idea of the complete

series of changes through which New Zealand is believed to have passed in

order to bring about its abnormally dense population of wingless birds.

First, we must suppose a land connection with some country inhabited by

struthious birds, from which the ancestral forms might be derived;

secondly, a separation into many considerable islands, in which the various

distinct species might become differentiated; thirdly, an elevation

bringing about the union of these islands to unite the distinct species in

one area; and fourthly, a subsidence of a large part of the area, leaving

the present islands with the various species crowded together.

If New Zealand has really gone through such a series of changes as here

suggested, some proofs of it might perhaps be obtained in the outlying

islands which were once, presumably, joined with it. And this gives great

importance to the statement of the aborigines of the Chatham Islands, that

the Apteryx formerly lived there but was exterminated about 1835. It is to

be hoped that some search will be made here and also in Norfolk Island, in

both of which it is not improbable remains either of Apteryx or Dinornis

might be discovered.

So far we find nothing to object to in the speculations of Captain Hutton,

with which, on the contrary, we almost wholly concur; but we cannot follow

him when he goes on to suggest an Antarctic continent uniting New Zealand

and Australia with South America, and probably also with South Africa, in

order to explain the existing distribution {480} of struthious birds. Our

best anatomists, as we have seen, agree that both Dinornis and Apteryx are

more nearly allied to the cassowaries and emus than to the ostriches and

rheas; and we see that the form of the sea-bottom suggests a former

connection with North Australia and New Guinea--the very region where these

types most abound, and where in all probability they originated. The

suggestion that all the struthious birds of the world sprang from a common

ancestor at no very remote period, and that their existing distribution is

due to direct land communication between the countries they \_now\_ inhabit,

is one utterly opposed to all sound principles of reasoning in questions of

geographical distribution. For it depends upon two assumptions, both of

which are at least doubtful, if not certainly false--the first, that their

distribution over the globe has never in past ages been very different from

what it is now; and the second, that the ancestral forms of these birds

never had the power of flight. As to the first assumption, 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 had the trogons of South America, Africa,

and tropical Asia. But besides this general evidence we have direct proof

that the struthious birds had a wider range in past times than now. 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."

As to the second point, we have the remarkable fact that all known birds of

this group have not only the rudiments of wing-bones, but also the

rudiments of wings, that is, an external limb bearing rigid quills or

largely-developed {481} plumes. In the cassowary these wing-feathers are

reduced to long spines like porcupine-quills, while even in the Apteryx,

the minute external wing bears a series of nearly twenty stiff quill-like

feathers.[123] These facts render it almost certain that the struthious

birds do not owe their imperfect wings to a direct evolution from a

reptilian type, but to a retrograde development from some low form of

winged birds, analogous to that which has produced the dodo and the

solitaire from the more highly-developed pigeon-type. Professor Marsh has

proved, that so far back as the Cretaceous period, the two great forms of

birds--those with a keeled sternum and fairly-developed wings, and those

with a convex keel-less sternum and rudimentary wings--already existed side

by side; while in the still earlier ArchÃ¦opteryx of the Jurassic period we

have a bird with well-developed wings, and therefore probably with a keeled

sternum. We are evidently, therefore, very far from a knowledge of the

earliest stages of bird life, and our acquaintance with the various forms

that have existed is scanty in the extreme; but we may be sure that birds

acquired wings, and feathers, and some power of flight, before they

developed a keeled sternum, since we see that bats with no such keel fly

very well. Since, therefore, the struthious birds all have perfect

feathers, and all have rudimentary wings, which are anatomically those of

true birds, not the rudimentary fore-legs of reptiles, and since we know

that in many higher groups of birds--as the pigeons and the rails--the

wings have become more or less aborted, and the keel of the sternum greatly

reduced in size by disuse, it seems probable that the very remote ancestors

of the rhea, the cassowary, and the apteryx, were true flying birds,

although not perhaps provided with a keeled sternum, or possessing very

great powers of flight. But in addition to the possible ancestral power of

flight, we have the undoubted fact that the rhea and the emu both swim

freely, the former having been seen swimming from island to island off the

coast of Patagonia. This, taken in connection with the wonderful aquatic

ostrich of the Cretaceous period discovered by Professor Marsh, opens {482}

up fresh possibilities of migration; while the immense antiquity thus given

to the group and their universal distribution in past time, renders all

suggestions of special modes of communication between the parts of the

globe in which their scattered remnants \_now\_ happen to exist, altogether

superfluous and misleading.

The bearing of this argument on our present subject is, that so far as

accounting for the presence of wingless birds in New Zealand is concerned,

we have nothing whatever to do with any possible connection, by way of a

southern continent or antarctic islands, with South America and South

Africa, because the nearest allies of its moas and kiwis are the

cassowaries and emus, and we have distinct indications of a former land

extension towards North Australia and New Guinea, which is exactly what we

require for the original entrance of the struthious type into the New

Zealand area.

\_Winged Birds and Lower Vertebrates of New Zealand.\_--Having given a pretty

full account of the New Zealand fauna elsewhere[124] I need only here point

out its bearing on the hypothesis now advanced, of the former

land-connection having been with North Australia, New Guinea, and the

Western Pacific Islands, rather than with the temperate regions of

Australia.

Of the Australian genera of birds, which are found also in New Zealand,

almost every one ranges also into New Guinea or the Pacific Islands, while

the few that do not extend beyond Australia are found in its northern

districts. As regards the peculiar New Zealand genera, all whose affinities

can be traced are allied to birds which belong to the tropical parts of the

Australian region; while the starling family, to which four of the most

remarkable New Zealand birds belong (the genera Creadion, Heterolocha, and

CallÃ¦as), is totally wanting in temperate Australia and is comparatively

scarce in the entire Australian region, but is abundant in the Oriental

region, with which New Guinea and the Moluccas are in easy communication.

It is certainly a most suggestive fact that there are more than sixty {483}

genera of birds peculiar to the Australian continent (with Tasmania), many

of them almost or quite confined to its temperate portions, and that no

single one of these should be represented in temperate New Zealand.[125]

The affinities of the living and more highly organised, no less than those

of the extinct and wingless birds, strikingly accord with the line of

communication indicated by the deep submarine bank connecting these

temperate islands with the tropical parts of the Australian region.

The reptiles, so far as they go, are quite in accordance with the birds.

The lizards belong to two genera, Lygosoma, which has a wide range in all

the tropics as well as in Australia; and Naultinus, a genus peculiar to New

Zealand, but belonging to a family--GeckonidÃ¦--spread over the whole of the

warmer parts of the world. Australia, with New Guinea, on the other hand,

has a peculiar family, and no less than twenty-one peculiar genera of

lizards, many of which are confined to its temperate regions, but no one of

them extends to temperate New Zealand.[126] The extraordinary lizard-like

\_Hatteria punctata\_ of New Zealand forms of itself a distinct order of

reptiles, in some respects intermediate between lizards and crocodiles, and

having therefore no affinity with any living animal.

The only representative of the Amphibia in New Zealand is a solitary frog

of a peculiar genus (\_Liopelma hochstetteri\_); but it has no affinity for

any of the Australian frogs, which are numerous, and belong to eleven

different families; while the Liopelma belongs {484} to a very distinct

family (DiscoglossidÃ¦), confined to the PalÃ¦arctic region.

Of the fresh-water fishes we need only say here, that none belong to

peculiar Australian types, but are related to those of temperate South

America or of Asia.

The Invertebrate classes are comparatively little known, and their modes of

dispersal are so varied and exceptional that the facts presented by their

distribution can add little weight to those already adduced. We will,

therefore, now proceed to the conclusions which can fairly be drawn from

the general facts of New Zealand natural history already known to us.

\_Deductions from the Peculiarities of the New Zealand Fauna.\_--The total

absence (or extreme scarcity) of mammals in New Zealand obliges us to place

its union with North Australia and New Guinea at a very remote epoch. We

must either go back to a time when Australia itself had not yet received

the ancestral forms of its present marsupials and monotremes, or we must

suppose that the portion of Australia with which New Zealand was connected

was then itself isolated from the mainland, and was thus without a

mammalian population. We shall see in our next chapter that there are

certain facts in the distribution of plants, no less than in the geological

structure of the country, which favour the latter view. But we must on any

supposition place the union very far back, to account for the total want of

identity between the winged birds of New Zealand and those peculiar to

Australia, and a similar want of accordance in the lizards, the fresh-water

fishes, and the more important insect-groups of the two countries. From

what we know of the long geological duration of the generic types of these

groups we must certainly go back to the earlier portion of the Tertiary

period at least, in order that there should be such a complete disseverance

as exists between the characteristic animals of the two countries; and we

must further suppose that, since their separation, there has been no

subsequent union or sufficiently near approach to allow of any important

intermigration, even of winged birds, between them. It seems probable,

therefore, that {485} the Bampton shoal west of New Caledonia, and Lord

Howe's Island further south, formed the western limits of that extensive

land in which the great wingless birds and other isolated members of the

New Zealand fauna were developed. Whether this early land extended eastward

to the Chatham Islands and southward to the Macquaries we have no means of

ascertaining, but as the intervening sea appears to be not more than about

1,500 fathoms deep it is quite possible that such an amount of subsidence

may have occurred. It is possible, too, that there may have been an

extension northward to the Kermadec Islands, and even further to the Tonga

and Fiji Islands, though this is hardly probable, or we should find more

community between their productions and those of New Zealand.

A southern extension towards the Antarctic continent at a somewhat later

period seems more probable, as affording an easy passage for the numerous

species of South American and Antarctic plants, and also for the identical

and closely allied fresh-water fishes of these countries.

The subsequent breaking up of this extensive land into a number of separate

islands in which the distinct species of moa and kiwi were developed--their

union at a later period, and the final submergence of all but the existing

islands, is a pure hypothesis, which seems necessary to explain the

occurrence of so many species of these birds in a small area but of which

we have no independent proof. There are, however, some other facts which

would be explained by it, as the presence of three peculiar but allied

genera of starlings, the three species of parrots of the genus Nestor, and

the six distinct rails of the genus Ocydromus, as well as the numerous

species in some of the peculiar New Zealand genera of plants, which seem

less likely to have been developed in a single area than when isolated, and

thus preserved from the counteracting influence of intercrossing.

In the present state of our knowledge these seem all the conclusions we can

arrive at from a study of the New Zealand fauna; but as we fortunately

possess a tolerably {486} full and accurate knowledge of the flora of New

Zealand, as well as of that of Australia and the south temperate lands

generally, it will be well to see how far these conclusions are supported

by the facts of plant distribution, and what further indications they

afford us of the early history of these most interesting countries. This

inquiry is of sufficient importance to occupy a separate chapter.

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CHAPTER XXII

THE FLORA OF NEW ZEALAND: ITS AFFINITIES AND PROBABLE ORIGIN

Relations of the New Zealand Flora to that of Australia--General

Features of the Australian Flora--The Floras of South-eastern and

South-western Australia--Geological Explanation of the Differences of

these two Floras--The Origin of the Australian Element in the New

Zealand Flora--Tropical Character of the New Zealand Flora

Explained--Species Common to New Zealand and Australia mostly Temperate

Forms--Why Easily Dispersed Plants have often Restricted

Ranges--Summary and Conclusion on the New Zealand Flora.

Although plants have means of dispersal far exceeding those possessed by

animals, yet as a matter of fact comparatively few species are carried for

very great distances, and the flora of a country taken as a whole usually

affords trustworthy indications of its past history. Plants, too, are more

numerous in species than the higher animals, and are almost always better

known; their affinities have been more systematically studied; and it may

be safely affirmed that no explanation of the origin of the fauna of a

country can be sound, which does not also explain, or at least harmonise

with, the distribution and relations of its flora. The distribution of the

two may be very different, but both should be explicable by the same series

of geographical changes.

The relations of the flora of New Zealand to that of Australia have long

formed an insoluble enigma for {488} botanists. Sir Joseph Hooker, in his

most instructive and masterly essay on the flora of Australia,

says:--"Under whatever aspect I regard the flora of Australia and of New

Zealand, I find all attempts to theorise on the possible causes of their

community of feature frustrated by anomalies in distribution, such as I

believe no two other similarly situated countries in the globe present.

Everywhere else I recognise a parallelism or harmony in the main common

features of contiguous floras, which conveys the impression of their

generic affinity, at least, being affected by migration from centres of

dispersion in one of them, or in some adjacent country. In this case it is

widely different. Regarding the question from the Australian point of view,

it is impossible in the present state of science to reconcile the fact of

Acacia, Eucalyptus, Casuarina, Callitris, &c., being absent in New Zealand,

with any theory of transoceanic migration that may be adopted to explain

the presence of other Australian plants in New Zealand; and it is very

difficult to conceive of a time or of conditions that could explain these

anomalies, except by going back to epochs when the prevalent botanical as

well as geographical features of each were widely different from what they

are now. On the other hand, if I regard the question from the New Zealand

point of view, I find such broad features of resemblance, and so many

connecting links that afford irresistible evidence of a close botanical

connection, that I cannot abandon the conviction that these great

differences will present the least difficulties to whatever theory may

explain the whole case." I will now state, as briefly as possible, what are

the facts above referred to as being of so anomalous a character, and there

is little difficulty in doing so, as we have them fully set forth, with

admirable clearness, in the essay above alluded to, and in the same

writer's \_Introduction to the Flora of New Zealand\_, only requiring some

slight modifications, owing to the later discoveries which are given in the

\_Handbook of the New Zealand Flora\_.

Confining ourselves always to flowering plants, we find that the flora of

New Zealand is a very poor one, considering the extent of surface, and the

favourable conditions of {489} soil and climate. It consists of 1,085

species (our own islands possessing about 1,500), but a very large

proportion of these are peculiar, there being no less than 800 endemic

species, and thirty-two endemic genera.

Out of the 285 species not peculiar to New Zealand, no less than 215 are

Australian, but a considerable number of these are also Antarctic, South

American, or European; so that there are only about 100 \_species\_

absolutely confined to New Zealand and Australia, and, what is important as

indicating a somewhat recent immigration, only some half-dozen of these

belong to \_genera\_ which are peculiar to the two countries, and hardly any

to the larger and more important Australian genera. Many, too, are rare

species in both countries and are often alpines.

Far more important are the relations of the genera and families of the two

countries. All the Natural Orders of New Zealand are found in Australia

except three--CoriariÃ¦, a widely-scattered group found in South Europe, the

Himalayas, and the Andes; EscallonieÃ¦, a widely distributed group; and

ChloranthaceÃ¦, found in Tropical Asia, Japan, Polynesia, and South America.

Out of a total of 310 New Zealand genera, no less than 248 are Australian,

and sixty of these are almost peculiar to the two countries, only

thirty-two however being absolutely confined to them.[127] In the three

large orders--CompositÃ¦, OrchideÃ¦, and GramineÃ¦, the genera are almost

identical in the two countries, while the species--in the two former

especially--are mostly distinct.

Here then we have apparently a wonderful resemblance between the New

Zealand flora and that of Australia, indicated by more than two-thirds of

the non-peculiar species, and more than nine-tenths of the non-peculiar

genera (255) being Australian. But now let us look at the other side of the

question.

There are in Australia seven great genera of plants, each containing more

than 100 species, all widely spread over {490} the country, and all highly

characteristic Australian forms,--Acacia, Eucalyptus, Melaleuca,

Leucopogon, Stylidium, Grevillea, and Hakea. These are entirely absent from

New Zealand, except one species of Leucopogon, a genus which also has

representatives in the Malayan and Pacific Islands. Sixteen more Australian

genera have over fifty species each, and of these eight are totally absent

from New Zealand, five are represented by one or two species, and only two

are fairly represented; but these two--Drosera and Helichrysum--are very

widespread genera, and might have reached New Zealand from other countries

than Australia.

But this by no means exhausts the differences between New Zealand and

Australia. No less than seven Australian Natural Orders--DilleniaceÃ¦,

BuettneriaceÃ¦, PolygaleÃ¦, TremandreÃ¦, CasuarineÃ¦, HÃ¦modoraceÃ¦, and XyrideÃ¦

are entirely wanting in New Zealand, and several others which are

excessively abundant and highly characteristic of the former country are

very poorly represented in the latter. Thus, LeguminosÃ¦ are extremely

abundant in Australia, where there are over 1,000 species belonging to

about 100 genera, many of them altogether peculiar to the country; yet in

New Zealand this great order is most scantily represented, there being only

five genera and thirteen species; and only two of these genera, Swainsonia

and Clianthus, are Australian, and as the latter consists of but two

species it may as well have passed from New Zealand to Australia as the

other way, or more probably from some third country to them both.[128]

GoodeniaceÃ¦ with ten genera and 220 species Australian, has but two species

in New Zealand--and one of these is a salt-marsh plant found also in

Tasmania and in Chile; and four other large Australian orders--RhamneÃ¦,

MyoporineÃ¦, ProteaceÃ¦ and SantalaceÃ¦, have very few representatives in New

Zealand.

We find, then, that the great fact we have to explain and account for is,

the undoubted affinity of the New {491} Zealand flora to that of Australia,

but an affinity almost exclusively confined to the least predominant and

least peculiar portion of that flora, leaving the most predominant, most

characteristic, and most widely distributed portion absolutely

unrepresented. We must however be careful not to exaggerate the amount of

affinity with Australia, apparently implied by the fact that nearly

six-sevenths of the New Zealand genera are also Australian, for, as we have

already stated, a very large number of these are European, Antarctic, South

American or Polynesian genera, whose presence in the two contiguous areas

only indicates a common origin. About one-eighth, only, are absolutely

confined to Australia and New Zealand (thirty-two genera), and even of

these several are better represented in New Zealand than in Australia, and

may therefore have passed from the former to the latter. No less than 174

of the New Zealand genera are temperate South American, many being also

Antarctic or European; while others again are especially tropical or

Polynesian; yet undoubtedly a larger proportion of the Natural Orders and

genera are common to Australia than to any other country, so that we may

say that the basis of the flora is Australian with a large intermixture of

northern and southern temperate forms and others which have remote

world-wide affinities.

\_General Features of the Australian Flora and its Probable Origin.\_--Before

proceeding to point out how the peculiarities of the New Zealand flora may

be best accounted for, it is necessary to consider briefly what are the

main peculiarities of Australian vegetation, from which so important a part

of that of New Zealand has evidently been derived.

The actual Australian flora consists of two great divisions--a temperate

and a tropical, the temperate being again divisible into an eastern and a

western portion. All that is most characteristic of the Australian flora

belongs to the temperate division (though these often overspread the whole

continent), in which are found almost all the remarkable Australian types

of vegetation and the numerous genera peculiar to this part of the world.

Contrary to what occurs in most other countries, the {492} tropical appears

to be less rich in species and genera than the temperate region, and what

is still more remarkable it contains fewer peculiar species, and very few

peculiar genera. Although the area of tropical Australia is about equal to

that of the temperate portions, and it has now been pretty well explored

botanically, it has probably not more than half as many species.[129]

Nearly 500 of its species are identical with Indian or Malayan plants, or

are very close representatives of them; while there are more than 200

Indian genera, confined for the most part to the tropical portion of

Australia. The remainder of the tropical flora consists of a few species

and many genera of temperate {493} Australia which range over the whole

continent, but these form only a small portion of the peculiarly Australian

genera.

These remarkable facts clearly point to one conclusion--that the flora of

tropical Australia is, comparatively, recent and derivative. If we imagine

the greater part of North Australia to have been submerged beneath the

ocean, from which it rose in the middle or latter part of the Tertiary

period, offering an extensive area ready to be covered by such suitable

forms of vegetation as could first reach it, something like the present

condition of things would inevitably arise. From the north, widespread

Indian and Malay plants would quickly enter, while from the south the most

dominant forms of warm-temperate Australia, and such as were best adapted

to the tropical climate and arid soil, would intermingle with them. Even if

numerous islands had occupied the area of Northern Australia for long

periods anterior to the final elevation, very much the same state of things

would result.

The existence in North and North-east Australia of enormous areas covered

with Cretaceous and other Secondary deposits, as well as extensive Tertiary

formations, lends support to the view, that during very long epochs

temperate Australia was cut off from all close connection with the tropical

and northern lands by a wide extent of sea; and this isolation is exactly

what was required, in order to bring about the wonderful amount of

specialisation and the high development manifested by the typical

Australian flora. Before proceeding further, however, let us examine this

flora itself, so far as regards its component parts and probable past

history.

\_The Floras of South-eastern and South-western Australia.\_--The

peculiarities presented by the south-eastern and south-western subdivisions

of the flora of temperate Australia are most interesting and suggestive,

and are, perhaps, unparalleled in any other part of the world. South-west

Australia is far less extensive than the south-eastern division--less

varied in soil and climate, with no lofty mountains, and much sandy desert;

yet, strange to say, it contains an equally rich flora and a far greater

proportion of peculiar species and genera of plants. As Sir {494} Joseph

Hooker remarks:--"What differences there are in conditions would, judging

from analogy with other countries, favour the idea that South-eastern

Australia, from its far greater area, many large rivers, extensive tracts

of mountainous country and humid forests, would present much the most

extensive flora, of which only the drier types could extend into

South-western Australia. But such is not the case; for though the far

greater area is much the best explored, presents more varied conditions,

and is tenanted by a larger number of Natural Orders and genera, these

contain fewer species by several hundreds."[130]

The fewer genera of South-western Australia are due almost wholly to the

absence of the numerous European, Antarctic, and South-American types found

in the south-eastern region, while in purely Australian types it is far the

richer, for while it contains most of those found in the east it has a

large number altogether peculiar to it; and Sir Joseph Hooker states that

"there are about 180 genera, out of 600 in South-western Australia, that

are either not found at all in South-eastern, or that are represented there

by a very few species only, and these 180 genera include nearly 1,100

species."

\_Geological Explanation of the Differences of these Two Floras.\_--These

facts again clearly point to the conclusion that South-western Australia is

the remnant of the more extensive and more isolated portion of the

continent in which the peculiar Australian flora was principally developed.

The existence there of a very large area of granite--800 miles in length by

nearly 500 in maximum width with detached masses 200 miles to the north and

500 miles to the east--indicates such an extension; for these {495}

granitic masses were certainly once buried under piles of stratified rock,

since denuded, and then formed the nucleus of the old Western Australian

continent. If we take the 1000-fathom line around the southern part of

Australia to represent the probable extension of this old land we shall see

that it would give a wide additional area south of the Great Australian

Bight, and form a continent which, even if the greater part of tropical

Australia were submerged, would be sufficient for the development of a

peculiar and abundant flora. We must also remember that an elevation of

6000 feet, added to the vast amount which has been taken away by

denudation, would change the whole country, including what are now the

deserts of the interior, into a mountainous and well-watered region.

But while this rich and peculiar flora was in process of formation, the

eastern portion of the continent must either have been widely separated

from the western or had perhaps not yet risen from the ocean. The whole of

this part of the country consists of PalÃ¦ozoic and Secondary formations

with granite and metamorphic rocks, the Secondary deposits being largely

developed on both sides of the central range, extending the whole length of

the continent from Tasmania to Cape York, and constituting the greater part

of the plateau of the Blue Mountains and other lofty ranges. During some

portion of the Secondary and Tertiary periods therefore, this side of

Australia must have been almost wholly submerged beneath the ocean; and if

we suppose that during this time the western part of the continent was at

nearly its maximum extent and elevation, we shall have a sufficient

explanation of the great difference between the flora of Western and

Eastern Australia, since the latter would only have been able to receive

immigrants from the former, at a later period, and in a more or less

fragmentary manner.

If we examine the geological map of Australia (given in Stanford's

Compendium of Geography and Travel, volume \_Australasia\_), we shall see

good reason to conclude that the eastern and the western divisions of the

country first existed as separate islands, and only became united at a

comparatively recent epoch. This is indicated by an {496} enormous stretch

of Cretaceous and Tertiary formations extending from the Gulf of

Carpentaria completely across the continent to the mouth of the Murray

River. During the Cretaceous period, therefore, and probably throughout a

considerable portion of the Tertiary epoch,[131] there must have been a

wide arm of the sea occupying this area, dividing the great mass of land on

the west--the true seat and origin of the typical Australian flora--from a

long but narrow belt of land on the east, indicated by the continuous mass

of Secondary and PalÃ¦ozoic formations already referred to which extend

uninterruptedly from Tasmania to Cape York. Whether this formed one

continuous land, or was broken up into islands, cannot be positively

determined; but the fact that no marine Tertiary beds occur in the whole of

this area, renders it probable that it was almost, if not quite,

continuous, and that it not improbably extended across to what is now New

Guinea. At this epoch, then (as shown in the accompanying map), Australia

may, not improbably, have consisted of a very large and fertile western

island, almost or quite extratropical, and extending from the Silurian

rocks of the Flinders range in South Australia, to about 150 miles west of

the present west coast, and southward to about 350 miles south of the Great

Australian Bight. To the east of this, at a distance of from 250 to 400

miles, extended in a north and south direction a long but comparatively

narrow island, stretching from far south of Tasmania to New Guinea; while

the crystalline and Secondary formations of central North Australia

probably indicate the existence of one or more large islands in that

direction.

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The white portions represent land; the shaded parts sea.

The existing land of Australia is shown in outline.]

The eastern and the western islands--with which we are now chiefly

concerned--would then differ considerably in their vegetation and animal

life. The western and more ancient land already possessed, in its main

features, the peculiar Australian flora, and also the ancestral forms of

its strange marsupial fauna, both of which it had probably received at some

earlier epoch by a temporary union with the Asiatic continent over what is

now the Java sea. Eastern Australia, on the other hand, possessed only the

rudiments of its existing mixed flora, derived from three distinct sources.

Some important fragments of the typical Australian vegetation had reached

it across the marine {498} strait, and had spread widely owing to the soil,

climate and general conditions being exactly suited to it: from the north

and north-east a tropical vegetation of Polynesian type had occupied

suitable areas in the north; while the extension southward of the Tasmanian

peninsula, accompanied, probably, as now, with lofty mountains, favoured

the immigration of south-temperate forms from whatever Antarctic lands or

islands then existed. This supposition is strikingly in harmony with what

is known of the ancient flora of this portion of Australia. In deposits

supposed to be of Eocene age in New South Wales and Victoria fossil plants

have been found showing a very different vegetation from that now existing.

Along with a few Australian types--such as Pittosporum, Knightia, and

Eucalyptus, there occur birches, alders, oaks, and beeches; while in

Tasmania in freshwater limestone, apparently of Miocene age, are found

willows, alders, birches, oaks, and beeches,[132] all except the latter

genus (Fagus) now quite extinct in Australia.[133] These temperate forms

probably indicate a more oceanic climate, cooler and moister than at

present. The union with Western Australia and the establishment of an arid

interior by modifying the climate may have led to the extinction of many of

these forms and their replacement by special Australian types more suited

to the new conditions.

At this time the marsupial fauna had not yet reached this eastern land,

which was, however, occupied in the north by some ancestral struthious

birds, which had entered it by way of New Guinea through some very ancient

continental extension, and of which the emu, the cassowaries, the extinct

Dromornis of Queensland, and the moas and kiwis of New Zealand, are the

modified descendants.

\_The Origin of the Australian Element in the New Zealand Flora.\_--We have

now brought down the history of Australia, as deduced from its geological

structure and the main features of its existing and Tertiary flora, to the

period {499} when New Zealand was first brought into close connection with

it, by means of a great north-western extension of that country, which, as

already explained in our last chapter, is so clearly indicated by the form

of the sea bottom (See Map, p. 471). The condition of New Zealand previous

to this event is very obscure. That it had long existed as a more or less

extensive land is indicated by its ancient sedimentary rocks; while the

very small areas occupied by Jurassic and Cretaceous deposits, imply that

much of the present land was then also above the sea-level. The country had

probably at that time a scanty vegetation of mixed Antarctic and Polynesian

origin; but now, for the first time, it would be open to the free

immigration of such Australian types as were suitable to its climate, and

which \_had already reached the tropical and sub-tropical portions of the

Eastern Australian island\_. It is here that we obtain the clue to those

strange anomalies and contradictions presented by the New Zealand flora in

its relation to Australia, which have been so clearly set forth by Sir

Joseph Hooker, and which have so puzzled botanists to account for. But

these apparent anomalies cease to present any difficulty when we see that

the Australian plants in New Zealand were acquired, not directly, but, as

it were, at second hand, by union with an island which itself had as yet

only received a portion of its existing flora. And then, further

difficulties were placed in the way of New Zealand receiving such an

adequate representation of that portion of the flora which had reached East

Australia as its climate and position entitled it to, by the fact of the

union being, not with the temperate, but with the tropical and sub-tropical

portions of that island, so that only those groups could be acquired which

were less exclusively temperate, and had already established themselves in

the warmer portion of their new home.[134]

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It is therefore no matter of surprise, but exactly what we should expect,

that the great mass of pre-eminently temperate Australian genera should be

absent from New Zealand, including the whole of such important families as,

DilleniaceÃ¦, TremandreÃ¦, BuettneriacÃ¦, PolygaleÃ¦, CasuarineÃ¦ and

HÃ¦modoraceÃ¦; while others, such as RutaceÃ¦, StackhousieÃ¦, RhamneÃ¦,

MyrtaceÃ¦, ProteaceÃ¦, and SantalaceÃ¦, are represented by only a few species.

Thus, too, we can explain the absence of \_all\_ the peculiar Australian

LeguminosÃ¦; for these were still mainly confined to the great western

island, along with the peculiar Acacias and Eucalypti, which at a later

period spread over the whole continent. It is equally accordant with the

view we are maintaining, that among the groups which Sir Joseph Hooker

enumerates as "keeping up the features of extra tropical Australia in its

tropical quarter," several should have reached New Zealand, such as

Drosera, some PittosporeÃ¦ and MyoporineÃ¦, with a few ProteaceÃ¦, LoganiaceÃ¦,

and RestiaceÃ¦; for most of these are not only found in tropical Australia,

but also in the Malayan and Pacific islands.

\_Tropical Character of the New Zealand Flora Explained.\_--In this origin of

the New Zealand fauna by a north-western route from North-eastern

Australia, we find also an explanation of the remarkable number of tropical

groups of plants found there: for though, as Sir Joseph Hooker has {501}

shown, a moist and uniform climate favours the extension of tropical forms

in the temperate zone, yet some means must be afforded them for reaching a

temperate island. On carefully going through the \_Handbook\_, and comparing

its indications with those of Bentham's \_Flora Australiensis\_, I find that

there are in New Zealand thirty-eight thoroughly tropical genera,

thirty-three of which are found in Australia--mostly in the tropical

portion of it, though a few are temperate, and these may have reached it

through New Zealand[135]. To these we must add thirty-two more genera,

which, though chiefly developed in temperate Australia, extend into the

tropical or sub-tropical portions of it, and may well have reached New

Zealand by the same route.

On the other hand we find but few New Zealand genera certainly derived from

Australia which are especially temperate, and it may be as well to give a

list of such as {502} do occur with a few remarks. They are sixteen in

number, as follows:--

1. Pennantia (1 sp.). This genus has a species in Norfolk Island,

indicating perhaps its former extension to the north-west.

2. Pomaderris (3 sp.). One \_species\_ inhabits Victoria and New Zealand,

indicating recent trans-oceanic migration.

3. Quintinia (2 sp.). This genus has winged seeds facilitating

migration.

4. Olearia (20 sp.). Seeds with pappus.

5. Craspedia (2 sp.). Seeds with pappus. Alpine; identical with

Australian species, and therefore of comparatively recent introduction.

6. Celmisia (25 sp.). Seeds with pappus. Only three Australian species,

two of which are identical with New Zealand forms, probably therefore

derived from New Zealand.

7. Ozothamnus (5 sp.). Seeds with pappus.

8. Epacris (4 sp.). Minute seeds. Some species are sub-tropical, and

they are all found in the northern (warmer) island of New Zealand.

9. Archeria (2 sp.). Minute seeds. A species common to E. Australia and

New Zealand.

10. Logania (3 sp.). Small seeds. Alpine plants.

11. Hedycarya (1 sp.).

12. Chiloglottis (1 sp.). Minute seeds. In Auckland Islands; alpine in

Australia.

13. Prasophyllum (1 sp.). Minute seeds. Identical with Australian

species, indicating recent transmission.

14. Orthoceras (1 sp.). Minute seeds. Identical with an Australian

species.

15. Alepyrum (1 sp.). Alpine, moss-like. An Antarctic type.

16. Dichelachne (3 sp.). Identical with Australian species. An awned

grass.

We thus see that there are special features in most of these plants that

would facilitate transmission across the sea between temperate Australia

and New Zealand, or to both from some Antarctic island; and the fact that

in several of them the species are absolutely identical shows that such

transmission has occurred in geologically recent times.

\_Species Common to New Zealand and Australia Mostly Temperate Forms.\_--Let

us now take the \_species\_ which are common to New Zealand and Australia,

but found nowhere else, and which must therefore have passed from one

country to the other at a more recent period than the mass of \_genera\_ with

which we have hitherto been dealing. These are ninety-six in number, and

they present a striking contrast to the similarly restricted \_genera\_ in

being wholly temperate in character, the entire list presenting only a

{503} single species which is confined to sub-tropical East Australia--a

grass (\_Apera arundinacea\_) only found in a few localities on the New

Zealand coast.

Now it is clear that the larger portion, if not the whole, of these plants

must have reached New Zealand from Australia (or in a few cases Australia

from New Zealand), by transmission across the sea, because we know there

has been no actual land connection during the Tertiary period, as proved by

the absence of all the Australian mammalia, and almost all the most

characteristic Australian birds, insects, and plants. The form of the

sea-bed shows that the distance could not have been less than 600 miles,

even during the greatest extension of Southern New Zealand and Tasmania;

and we have no reason to suppose it to have been less, because in other

cases an equally abundant flora of identical species has reached islands at

a still greater distance--notably in the case of the Azores and Bermuda.

The character of the plants is also just what we should expect: for about

two-thirds of them belong to genera of world-wide range in the temperate

zones, such as Ranunculus, Drosera, Epilobium, Gnaphalium, Senecio,

Convolvulus, Atriplex, Luzula, and many sedges and grasses, whose

exceptionally wide distribution shows that they possess exceptional powers

of dispersal and vigour of constitution, enabling them not only to reach

distant countries, but also to establish themselves there. Another set of

plants belong to especially Antarctic or south temperate groups, such as

Colobanthus, AcÃ¦na, Gaultheria, Pernettya, and Muhlenbeckia, and these may

in some cases have reached both Australia and New Zealand from some now

submerged Antarctic island. Again, about one-fourth of the whole are alpine

plants, and these possess two advantages as colonisers. Their lofty

stations place them in the best position to have their seeds carried away

by winds; and they would in this case reach a country which, having derived

the earlier portion of its flora from the side of the tropics, would be

likely to have its higher mountains and favourable alpine stations to a

great extent unoccupied, or occupied by plants unable to compete with

specially adapted alpine groups. {504}

Fully one-third of the exclusively Australo-New Zealand species belong to

the two great orders of the sedges and the grasses; and there can be no

doubt that these have great facilities for dispersion in a variety of ways.

Their seeds, often enveloped in chaffy glumes, would be carried long

distances by storms of wind, and even if finally dropped into the sea would

have so much less distance to reach the land by means of surface currents;

and Mr. Darwin's experiments show that even cultivated oats germinated

after 100 days' immersion in sea-water. Others have hispid awns by which

they would become attached to the feathers of birds, and there is no doubt

this is an effective mode of dispersal. But a still more important point

is, probably, that these plants are generally, if not always,

wind-fertilised, and are thus independent of any peculiar insects, which

might be wanting in the new country.

\_Why Easily-Dispersed Plants have often Restricted Ranges.\_--This last

consideration throws light on a very curious point, which has been noted as

a difficulty by Sir Joseph Hooker, that plants which have most clear and

decided powers of dispersal by wind or other means, have \_not\_ generally

the widest specific range; and he instances the small number of CompositÃ¦

common to New Zealand and Australia. But in all these cases it will, I

think, be found that although the \_species\_ have not a wide range the

\_genera\_ often have. In New Zealand, for instance, the CompositÃ¦ are very

abundant, there being no less than 167 species, almost all belonging to

Australian genera, yet only about one-sixteenth of the whole are identical

in the two countries. The explanation of this is not difficult. Owing to

their great powers of dispersal, the Australian CompositÃ¦ reached New

Zealand at a very remote epoch, and such as were adapted to the climate and

the means of fertilisation established themselves; but being highly

organised plants with great flexibility of organisation, they soon became

modified in accordance with the new conditions, producing many special

forms in different localities; and these, spreading widely, soon took

possession of all suitable stations. Henceforth immigrants from Australia

had to compete {505} with these indigenous and well-established plants, and

only in a few cases were able to obtain a footing; whence it arises that we

have many Australian types, but few Australian species, in New Zealand, and

both phenomena are directly traceable to the combination of great powers of

dispersal with a high degree of adaptability. Exactly the same thing occurs

with the still more highly specialised OrchideÃ¦. These are not

proportionally so numerous in New Zealand (thirty-eight species), and this

is no doubt due to the fact that so many of them require

insect-fertilisation often by a particular family or genus (whereas almost

any insect will fertilise CompositÃ¦), and insects of all orders are

remarkably scarce in New Zealand.[136] This would at once prevent the

establishment of many of the orchids which may have reached the islands,

while those which did find suitable fertilisers and other favourable

conditions would soon become modified into new species. It is thus quite

intelligible why only three species of orchids are identical in Australia

and New Zealand, although their minute and abundant seeds must be dispersed

by the wind almost as readily as the spores of ferns.

Another specialised group--the ScrophularineÃ¦--abounds in New Zealand,

where there are sixty-two species; but though almost all the genera are

Australian only three species are so. Here, too, the seeds are usually very

small, and the powers of dispersal great, as shown by several European

genera--Veronica, Euphrasia, and Limosella, being found in the southern

hemisphere.

Looking at the whole series of these Australo-New Zealand plants, we find

the most highly specialised groups--CompositÃ¦, ScrophularineÃ¦,

OrchideÃ¦--with a small proportion of identical species (one-thirteenth to

one twentieth), the less highly specialised--RanunculaceÃ¦, OnagrariÃ¦ and

EriceÃ¦--with a higher proportion (one-ninth to one-sixth), and the least

specialised--JunceÃ¦, {506} CyperaceÃ¦ and GramineÃ¦--with the high proportion

in each case of one-fourth. These nine are the most important New Zealand

orders which contain species common to that country and Australia and

confined to them; and the marked correspondence they show between high

specialisation and want of \_specific\_ identity, while the \_generic\_

identity is in all cases approximately equal, points to the conclusion that

the means of diffusion are, in almost all plants ample, when long periods

of time are concerned, and that diversities in this respect are not so

important in determining the peculiar character of a derived flora, as

adaptability to varied conditions, great powers of multiplication, and

inherent vigour of constitution. This point will have to be more fully

discussed in treating of the origin of the Antarctic and north temperate

members of the New Zealand flora.

\_Summary and Conclusion on the New Zealand Flora.\_--Confining ourselves

strictly to the direct relations between the plants of New Zealand and of

Australia, as I have done in the preceding discussion, I think I may claim

to have shown that the union between the two countries in the latter part

of the Secondary epoch at a time when Eastern Australia was widely

separated from Western Australia (as shown by its geological formation and

by the contour of the sea-bottom) does sufficiently account for all the

main features of the New Zealand flora. It shows why the basis of the flora

is fundamentally Australian both as regards orders and genera, for it was

due either to a direct land connection or a somewhat close approximation

between the two countries. It shows also why the great mass of typical

Australian forms are unrepresented, for the Australian flora is typically

\_western\_ and \_temperate\_, and New Zealand received its immigrants from the

\_eastern\_ island which had itself received only a fragment of this flora,

and from the \_tropical\_ end of this island, and thus could only receive

such forms as were not exclusively temperate in character. It shows,

further, why New Zealand contains such a very large proportion of tropical

forms, for we see that it derived the main portion of its flora directly

from the tropics. Again, this hypothesis shows us why, though {507} the

specially Australian \_genera\_ in New Zealand are largely tropical or

sub-tropical, the specially Australian \_species\_ are wholly temperate or

alpine; for these are comparatively recent arrivals, they must have

migrated across the sea in the temperate zone, and these temperate and

alpine forms are exactly such as would be best able to establish themselves

in a country already stocked mainly by tropical forms and their modified

descendants. This hypothesis further fulfils the conditions implied in Sir

Joseph Hooker's anticipation that--"these great differences (of the floras)

will present the least difficulties to whatever theory may explain the

whole case,"--for it shows that these differences are directly due to the

history and development of the Australian flora itself, while the

resemblances depend upon the most certain cause of all such broad

resemblances--close proximity or actual land connection.

One objection will undoubtedly be made to the above theory,--that it does

not explain why some species of the prominent Australian genera Acacia,

Eucalyptus, Melaleuca, Grevillea, &c., have not reached New Zealand in

recent times along with the other temperate forms that have established

themselves. But it is doubtful whether any detailed explanation of such a

negative fact is possible, while general explanations sufficient to cover

it are not wanting. Nothing is more certain than that numerous plants never

run wild and establish themselves in countries where they nevertheless grow

freely if cultivated; and the explanation of this fact given by Mr.

Darwin--that they are prevented doing so by the competition of better

adapted forms--is held to be sufficient. In this particular case, however,

we have some very remarkable evidence of the fact of their non-adaptation.

The intercourse between New Zealand and Europe has been the means of

introducing a host of common European plants,--more than 150 in number, as

enumerated at the end of the second volume of the \_Handbook\_; yet, although

the intercourse with Australia has probably been greater, only two or three

Australian plants have similarly established themselves. More remarkable

still, Sir Joseph Hooker states: {508} "I am informed that the late Mr.

Bidwell habitually scattered Australian seeds during his extensive travels

in New Zealand." We may be pretty sure that seeds of such excessively

common and characteristic groups as \_Acacia\_ and \_Eucalyptus\_ would be

among those so scattered, yet we have no record of any plants of these or

other peculiar Australian genera ever having been found wild, still less of

their having spread and taken possession of the soil in the way that many

European plants have done. We are, then, entitled to conclude that the

plants above referred to have not established themselves in New Zealand

(although their seeds may have reached it) because they could not

successfully compete with the indigenous flora which was already well

established and better adapted to the conditions of climate and of the

organic environment. This explanation is so perfectly in accordance with a

large body of well-known facts, including that which is known to every

one--how few of our oldest and hardiest garden plants ever run wild--that

the objection above stated will, I feel convinced, have no real weight with

any naturalists who have paid attention to this class of questions.

\* \* \* \* \*

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CHAPTER XXIII

ON THE ARCTIC ELEMENT IN SOUTH TEMPERATE FLORAS

European Species and Genera of Plants in the Southern

Hemisphere--Aggressive Power of the Scandinavian Flora--Means by which

Plants have Migrated from North to South--Newly moved Soil as Affording

Temporary Stations to Migrating Plants--Elevation and Depression of the

Snow-line as Aiding the Migration of Plants--Changes of Climate

Favourable to Migration--The Migration from North to South has been

long going on--Geological Changes as Aiding Migration--Proofs of

Migration by way of the Andes--Proofs of Migration by way of the

Himalayas and Southern Asia--Proofs of Migration by way of the African

Highlands--Supposed Connection of South Africa and Australia--The

Endemic Genera of Plants in New Zealand--The Absence of Southern Types

from the Northern Hemisphere--Concluding Remarks on the New Zealand and

South Temperate Floras.

We have now to deal with another portion of the New Zealand flora which

presents perhaps equal difficulties--that which appears to have been

derived from remote parts of the north and south temperate zones; and this

will lead us to inquire into the origin of the northern or Arctic element

in all the south temperate floras.

More than one-third of the entire number of New Zealand genera (115) are

found also in Europe, and even fifty-eight species are identical in these

remote parts of the world. Temperate South America has seventy-four genera

in common with New Zealand, and there are even eleven species identical in

the two countries, as well as thirty-two which are close allies or

representative species. {510} A considerable number of these northern or

Antarctic plants and many more which are representative species, are found

also in Tasmania and in the mountains of temperate Australia; and Sir

Joseph Hooker gives a list of thirty-eight species very characteristic of

Europe and Northern Asia, but almost or quite unknown in the warmer

regions, which yet reappear in temperate Australia. Other genera seem

altogether Antarctic--that is, confined to the extreme southern lands and

islands; and these often have representative species in Southern America,

Tasmania, and New Zealand, while others occur only in one or two of these

areas. Many north temperate genera also occur in the mountains of South

Africa. On the other hand, few if any of the peculiar Australian or

Antarctic types have spread northwards, except some of the former which

have reached the mountains of Borneo, and a few of the latter which spread

along the Andes to Mexico.

On these remarkable facts, of which I have given but the barest outline,

Sir Joseph Hooker makes the following suggestive observations:--

"When I take a comprehensive view of the vegetation of the Old World, I am

struck with the appearance it presents of there being a continuous current

of vegetation (if I may so fancifully express myself) from Scandinavia to

Tasmania; along, in short, the whole extent of that arc of the terrestrial

sphere which presents the greatest continuity of land. In the first place

Scandinavian genera, and even species, reappear everywhere from Lapland and

Iceland to the tops of the Tasmanian Alps, in rapidly diminishing numbers

it is true, but in vigorous development throughout. They abound on the Alps

and Pyrenees, pass on to the Caucasus and Himalayas, thence they extend

along the Khasia Mountains, and those of the peninsulas of India to those

of Ceylon and the Malayan Archipelago (Java and Borneo), and after a hiatus

of 30Â° they appear on the Alps of New South Wales, Victoria, and Tasmania,

and beyond these again on those of New Zealand and the Antarctic Islands,

many of the species remaining unchanged throughout! It matters not what the

vegetation of the bases and flanks of these mountains may be; the northern

species may be {511} associated with alpine forms of Germanic, Siberian,

Oriental, Chinese, American, Malayan, and finally Australian, and Antarctic

types; but whereas these are all, more or less, local assemblages, the

Scandinavian asserts his prerogative of ubiquity from Britain to beyond its

antipodes."[137]

It is impossible to place the main facts more forcibly before the reader

than in the above striking passage. It shows clearly that this portion of

the New Zealand flora is due to wide-spread causes which have acted with

even greater effect in other south temperate lands, and that in order to

explain its origin we must grapple with the entire problem of the transfer

of the north temperate flora to the southern hemisphere. Taking, therefore,

the facts as given by Sir Joseph Hooker in the works already referred to, I

shall discuss the whole question broadly, and shall endeavour to point out

the general laws and subordinate causes that, in my opinion, have been at

work in bringing about the anomalous phenomena of distribution he has done

so much to make known and to elucidate.

\_Aggressive Power of the Scandinavian Flora.\_--The first important fact

bearing upon this question is the wonderful aggressive and colonising power

of the Scandinavian flora, as shown by the way in which it establishes

itself in any temperate country to which it may gain access. About 150

species have thus established themselves in New Zealand, often taking

possession of large tracts of country; about the same number are found in

Australia, and nearly as many in the Atlantic states of America, where they

form the commonest weeds. Whether or not we accept Mr. Darwin's explanation

of this power as due to development in the most extensive land area of the

globe where competition has been most severe and long-continued, the fact

of the existence of this power remains, and we can see how important an

agent it must be in the formation of the floras of any lands to which these

aggressive plants have been able to gain access.

But not only are these plants pre-eminently capable of holding their own in

any temperate country in the world, but they also have exceptional powers

of migration and {512} dispersal over seas and oceans. This is especially

well shown by the case of the Azores, where no less than 400 out of a total

of 478 flowering plants are identical with European species. These islands

are more than 800 miles from Europe, and, as we have already seen in

Chapter XII., there is no reason for supposing that they have ever been

more nearly connected with it than they are now, since an extension of the

European coast to the 1,000-fathom line would very little reduce the

distance. Now it is a most interesting and suggestive fact that more than

half the European genera which occur in the Australian flora occur also in

the Azores, and in several cases even the species are identical in

both.[138] The importance of such a case as this cannot be exaggerated,

because it affords a demonstration of the power of the very plants in

question to pass over wide areas of sea, some no doubt wholly through the

air, carried by storms in the same way as the European birds and insects

which annually reach the Azores, others by floating on the waters, or by a

combination of the two methods; while some may have been carried by aquatic

birds, to whose feathers many seeds have the power of attaching themselves,

and some even in the stomachs of fruit or seed eating birds. We have in

such facts as these a complete disproof of the necessity for those great

changes of sea and land which are continually appealed to by those who

think land-connection the only efficient means of accounting for the

migration of animals or plants; but at the same time we do not neglect to

make the fullest use of such moderate changes as all the evidence at our

command leads us to believe have actually occurred, and especially of the

former existence of intermediate islands, so often indicated by shoals in

the midst of the deepest oceans.

\_Means by which Plants have migrated from North to South.\_--But if plants

can thus pass in considerable numbers and variety over wide seas and

oceans, it must be yet more easy for them to traverse continuous areas of

land, whereever mountain-chains offer suitable stations at moderate {513}

intervals on which they might temporarily establish themselves. The

facilities afforded for the transmission of plants by mountains has hardly

received sufficient attention. The numerous land-slips, the fresh surfaces

of broken rock and precipice, the \_debris\_ of torrents, and the moraines

deposited by glaciers, afford numerous unoccupied stations on which

wind-borne seeds have a good chance of germinating. It is a well-known fact

that fresh surfaces of soil or rock, such as are presented by railway

cuttings and embankments, often produce plants strange to the locality,

which survive for a few years, and then disappear as the normal vegetation

gains strength and permanence.[139] But such a surface {514} will, in the

meantime, have acted as a fresh centre of dispersal; and thus a plant might

pass on step by step, by means of stations temporarily occupied, till it

reached a district {515} where, the general conditions being more

favourable, it was able to establish itself as a permanent member of the

flora. Such, generally speaking, was probably the process by which the

Scandinavian flora has made its way to the southern hemisphere; but it

could hardly have done so to any important extent without the aid of those

powerful causes explained in our eighth chapter--causes which acted as a

constantly recurrent motive-power to produce that "continuous current of

vegetation" from north to south across the whole width of the tropics

referred to by Sir Joseph Hooker. Those causes were, the repeated changes

{516} of climate which, during all geological time, appear to have occurred

in both hemispheres, culminating at rare intervals in glacial epochs, and

which have been shown to depend upon changes of excentricity of the earth's

orbit and the occurrence of summer or winter in \_aphelion\_, in conjunction

with the slower and more irregular changes of geographical conditions;

these combined causes acting chiefly through the agency of heat-bearing

oceanic currents, and of snow- and ice-collecting highlands. Let us now

briefly consider how such changes would act in favouring the dispersal of

plants.

\_Elevation and Depression of the Snow Line as Aiding the Migration of

Plants.\_--We have endeavoured to show (in an earlier portion of this

volume) that wherever geographical or physical conditions were such as to

produce any considerable amount of perpetual snow, this would be increased

whenever a high degree of excentricity concurred with winter in \_aphelion\_,

and diminished during the opposite phase. On all mountain ranges,

therefore, which reached above the snow-line, there would be a periodical

increase and decrease of snow, and when there were extensive areas of

plateau at about the same level, the lowering of the snow-line might cause

such an increased accumulation of snow as to produce great glaciers and

ice-fields, such as we have seen occurred in South Africa during the last

period of high excentricity. But along with such depression of the line of

perpetual snow there would be a corresponding depression of the alpine and

sub-alpine zones suitable for the growth of an arctic and temperate

vegetation, and, what is perhaps more important, the depression would

necessarily produce a great \_extension\_ of the area of these zones on all

high mountains, because as we descend the average slopes become less

abrupt,--thus affording a number of new stations suitable for such

temperate plants as might first reach them. But just above and below the

snow-line is the area of most powerful disintegration and denudation, from

the alternate action of frost and sun, of ice and water; and thus the more

extended area would be subject to the constant occurrence of land-slips,

berg-falls, and floods, with their {517} accompanying accumulations of

\_dÃ©bris\_ and of alluvial soil, affording innumerable stations in which

solitary wind-borne seeds might germinate and temporarily establish

themselves.

This lowering and rising of the snow-line each 10,500 years during periods

of high excentricity, would occur in the northern and southern hemispheres

alternately; and where there were high mountains within the tropics the two

would probably overlap each other, so that the northern depression would

make itself felt in a slight degree even across the equator some way into

the southern hemisphere, and \_vice versÃ¢\_; and even if the difference of

the height of perpetual snow at the two extremes did not average more than

a few hundred feet, this would be amply sufficient to supply the new and

unoccupied stations needful to facilitate the migration of plants. It is

well known that all great mountain ranges have undergone such fluctuations,

as proved by ice-marks below the present level of snow and ice.

But the differences of temperature in the two hemispheres caused by the sun

being in \_perihelion\_ in the winter of the one while it was in \_aphelion\_

during the same season in the other, would necessarily lead to increased

aÃ«rial and marine currents, as already explained; and whenever geographical

conditions were such as to favour the production of glaciation in any area

these effects would become more powerful, and would further aid in the

dispersal of the seeds of plants.

\_Changes of Climate Favourable to Migration.\_--It is clear then, that

during periods when no glacial epochs were produced in the northern

hemisphere, and even when a mild climate extended over the whole polar

area, alternate changes of climate favouring the dispersal of plants would

occur on all high mountains, and with particular force on such as rise

above the snow-line. But during that long-continued, though comparatively

recent, phase of high excentricity which produced an extensive glaciation

in the northern hemisphere and local glaciations in the southern, these

risings and lowerings of the snow-line on all mountain ranges would have

been at a maximum, and {518} would have been increased by the depression of

the ocean which must have arisen from such a vast bulk of water being

locked up in land-ice, and which depression would have produced the same

effect as a general elevation of all the continents. At this time, too,

aÃ«rial currents would have attained their maximum of force in both

hemispheres; and this would greatly facilitate the dispersal of all

wind-borne seeds as well as of those carried in the plumage or in the

stomachs of birds, since we have seen, by the cases of the Azores and

Bermuda, how vastly the migratory powers of birds are increased by a stormy

atmosphere.

\_Migration from North to South has been long going on.\_--Now, if each phase

of colder and warmer mountain-climate--each alternate depression and

elevation of the snow-line, only helped on the migration of a few species

some stages of the long route from the north to the south temperate

regions, yet, during the long course of the Tertiary period there might

well have arisen that representation of the northern flora in the southern

hemisphere which is now so conspicuous. For it is very important to remark

that it is not the existing flora alone that is represented, such as might

have been conveyed during the last glacial epoch only; but we find a whole

series of northern types evidently of varying degrees of antiquity, while

even some genera characteristic of the southern hemisphere appear to have

been originally derived from Europe. Thus Eucalyptus and Metrosideros have

been determined by Dr. Ettingshausen from their fruits in the Eocene beds

of Sheppey, while Pimelea, Leptomeria and four genera of ProteaceÃ¦ have

been recognised by Professor Heer in the Miocene of Switzerland; and the

former writer has detected fifty-five Australian forms in the Eocene plant

beds of HÃ¤ring (? Belgium).[140] Then we have such peculiar genera {519} as

Pachychladon and Notothlaspi of New Zealand said to have affinities with

Arctic plants, while Stilbocarpa--another peculiar New Zealand genus--has

its nearest allies in the Himalayan and Chinese Aralias. Following these

are a whole host of very distinct species of northern genera which may date

back to any part of the Tertiary period, and which occur in every south

temperate land. Then we have closely allied representative species of

European or Arctic plants; and, lastly, a number of identical species,--and

these two classes are probably due entirely to the action of the last great

glacial epoch, whose long continuance, and the repeated fluctuations of

climate with which it commenced and terminated, rendered it an agent of

sufficient power to have brought about this result.

Here, then, we have that constant or constantly recurrent process of

dispersal acting throughout long periods with varying power--that

"continuous current of vegetation" as it has been termed, which the facts

demand; and the extraordinary phenomenon of the species and genera of

European and even of Arctic plants being represented abundantly in South

America, Australia, and New Zealand, thus adds another to the long series

of phenomena which are rendered intelligible by frequent alternations of

warmer and colder climates in either hemisphere, culminating, at long

intervals and in favourable situations, in actual glacial epochs.

\_Geological Changes as Aiding Migration.\_--It will be well also to notice

here, that there is another aid to dispersion dependent upon the changes

effected by denudation during the long periods included in the duration of

the species and genera of plants. A considerable number of {520} the plants

of the Miocene period of Europe were so much like existing species that

although they have generally received fresh names they may well have been

identical; and a large proportion of the vegetation during the whole

Tertiary period consisted of genera which are still living.[141] But from

what is now known of the rate of sub-aÃ«rial denudation, we are sure, that

during each division of this period many mountain chains must have been

considerably lowered, while we know that some of the existing ranges have

been greatly elevated. Ancient volcanoes, too, have been destroyed by

denudation, and new ones have been built up, so that we may be quite sure

that ample means for the transmission of temperate plants across the

tropics, may have existed in countries where they are now no longer to be

found. The great mountain masses of Guiana and Brazil, for example, must

have been far more lofty before the sedimentary covering was denuded from

their granitic bosses and metamorphic peaks, and may have aided the

southern migration of plants before the final elevation of the Andes. And

if Africa presents us with an example of a continent of vast antiquity, we

may be sure that its great central plateaux once bore far loftier mountain

ranges before they were reduced to their present condition by long ages of

denudation.

\_Proofs of Migration by Way of the Andes.\_--We are now prepared to apply

the principles above laid down to the explanation of the character and

affinities of the various portions of the north temperate flora in the

southern hemisphere, and especially in Australia and New Zealand.

At the present time the only unbroken chain of highlands and mountains

connecting the Arctic and north temperate with the Antarctic lands is to be

found in the American continent, the only break of importance being the

comparatively low Isthmus of Panama, where there is {521} a distance of

about 300 miles occupied by rugged forest-clad hills, between the lofty

peaks of Veragua and the northern extremity of the Andes of New Grenada.

Such distances are, as we have already seen, no barrier to the diffusion of

plants; and we should accordingly expect that this great continuous

mountain-chain has formed the most effective agent in aiding the southward

migration of the Arctic and north temperate vegetation. We do find, in

fact, not only that a large number of northern genera and many species are

scattered all along this line of route, but that at the end of the long

journey, in Southern Chile and Fuegia, they have established themselves in

such numbers as to form an important part of the flora of those countries.

From the lists given in the works already referred to, it appears that

there are between sixty and seventy northern genera in Fuegia and Southern

Chile, while about forty of the species are absolutely identical with those

of Europe and the Arctic regions. Considering how comparatively little the

mountains of South Temperate America are yet known, this is a very

remarkable result, and it proves that the transmission of species must have

gone on up to comparatively recent times. Yet, as only a few of these

species are now found along the line of migration, we see that they only

occupied such stations temporarily; and we may connect their disappearance

with the passing away of the last glacial period which, by raising the

snow-line, reduced the area on which alone they could exist, and exposed

them to the competition of indigenous plants from the belt of country

immediately below them.

Now, just as these numerous species and genera have undoubtedly passed

along the great American range of mountains, although only now found at its

two extremes, so others have doubtless passed on further; and have found

more suitable stations or less severe competition in the Antarctic

continent and islands, in New Zealand, in Tasmania, and even in Australia

itself. The route by which they may have reached these countries is easily

marked out. Immediately south of Cape Horn, at a distance of only 500

miles, are the South Shetland Islands and Graham's Land, whence the

Antarctic continent or a {522} group of large islands probably extends

across or around the south polar area to Victoria Land and thence to AdÃ©lie

Land. The outlying Young Island, 12,000 feet high, is about 750 miles south

of the Macquarie Islands, which may be considered a southern outlier of the

New Zealand group; and the Macquarie Islands are about the same distance

from the 1,000-fathom line at a point marking the probable southern

extension of Tasmania. Other islands may have existed at intermediate

points; but, even as it is, these distances are not greater than we know

are traversed by plants both by flotation and by aÃ«rial currents,

especially in such a stormy atmosphere as that of the Antarctic regions.

Now, we may further assume, that what we know occurred within the Arctic

circle also took place in the Antarctic--that is, that there have been

alternations of climate during which some portion of what are now ice-clad

lands became able to support a considerable amount of vegetation.[142]

During such periods there would be a steady migration of plants from all

southern circumpolar countries to people the comparatively unoccupied

continent, and the southern extremity of America being considerably the

nearest, and also being the best stocked with those northern types which

have such great powers of migration and colonisation, such plants would

form the bulk of the Antarctic vegetation, and during the continuance of

the milder southern climate would occupy the whole area.

When the cold returned and the land again became ice-clad, these plants

would be crowded towards the outer margins of the Antarctic land and its

islands, and some of them would find their way across the sea to such

countries as offered on their mountain summits suitable cool stations; and

as this process of alternately receiving plants from Chile and Fuegia and

transmitting them in all directions from the central Antarctic land may

have been {523} repeated several times during the Tertiary period, we have

no difficulty in understanding the general community between the European

and Antarctic plants found in all south temperate lands. Kerguelen's Land

and The Crozets are within about the same distance from the Antarctic

continent as New Zealand and Tasmania, and we need not therefore be

surprised at finding in each of these islands some Fuegian species which

have not reached the others. Of course, there will remain difficulties of

detail, as there always must remain, so long as our knowledge of the past

changes of the earth's surface and the history of the particular plants

concerned is so imperfect. Sir Joseph Hooker notes, for example, the

curious fact that several CompositÃ¦ common to three such remote localities

as the Auckland Islands, Fuegia, and Kerguelen's Land, have no pappus or

seed-down, while such as have pappus are in no case common even to two of

these islands. Without knowing the exact history and distribution of the

genera to which these plants belong it would be useless to offer any

conjecture, except that they are ancient forms which may have survived

great geographical changes, or may have some peculiar and exceptional means

of dispersion.

\_Proofs of Migration by way of the Himalayas and Southern Asia.\_--But

although we may thus explain the presence of a considerable portion of the

European element in the floras of New Zealand and Australia, we cannot

account for the whole of it by this means, because Australia itself

contains a host of European and Asiatic genera of which we find no trace in

New Zealand or South America, or any other Antarctic land. We find, in

fact, in Australia two distinct sets of European plants. First we have a

number of species identical with those of Northern Europe or Asia (of the

most characteristic of which--thirty-eight in number--Sir Joseph Hooker

gives a list); and in the second place a series of European genera usually

of a somewhat more southern character, mostly represented by very distinct

species, and all absent from New Zealand; such as Clematis, Papaver,

Cleome, Polygala, Lavatera, Ajuga, &c. Now of the first set--the North

European \_species\_--about three-fourths occur in some parts of America,

{524} and about half in South Temperate America or New Zealand; whence we

may conclude that most of these, as well as some others, have reached

Australia by the route already indicated. The second set of

Australo-European genera, however, and many others characteristic of the

South European or the Himalayan flora, have probably reached Australia by

way of the mountains of Southern Asia, Borneo, the Moluccas, and New

Guinea, at a somewhat remote period when loftier ranges and some

intermediate peaks may have existed, sufficient to carry on the migration

by the aid of the alternate climatal changes which are known to have

occurred. The long belt of Secondary and PalÃ¦ozoic formations in East

Australia from Tasmania to Cape York continued by the lofty ranges of New

Guinea, indicates the route of this immigration, and sufficiently explains

how it is that these northern types are almost wholly confined to this part

of the Australian continent. Some of the earlier immigrants of this class

no doubt passed over to New Zealand and now form a portion of the peculiar

genera confined to these two countries; but most of them are of later date,

and have thus remained in Australia only.

\_Proofs of Migration by way of the African Highlands.\_--It is owing to this

twofold current of vegetation flowing into Australia by widely different

routes that we have in this distant land a better representation of the

European flora, both as regards species and genera, than in any other part

of the southern hemisphere; and, so far as I can judge of the facts, there

is no general phenomenon--that is, nothing in the distribution of genera

and other groups of plants as opposed to cases of individual species--that

is not fairly accounted for by such an origin. It further receives support

from the case of South Africa, which also contains a large and important

representation of the northern flora. But here we see no indications (or

very slight ones) of that southern influx which has given Australia such a

community of vegetation with the Antarctic lands. There are no less than

sixty \_genera\_ of strictly north temperate plants in South Africa, none of

which occur in Australia; while very few of the \_species\_, so

characteristic of Australia, New Zealand, and Fuegia, are found there. It

{525} is clear, therefore, that South Africa has received its European

plants by the direct route through the Abyssinian highlands and the lofty

equatorial mountains, and mostly at a distant period when the conditions

for migration were somewhat more favourable than they are now. The much

greater directness of the route from Northern Europe to South Africa than

to Australia; and the existence even now of lofty mountains and extensive

highlands for a large portion of the distance, will explain (what Sir

Joseph Hooker notes as "a very curious fact") why South Africa has more

very northern European \_genera\_ than Australia, while Australia has more

identical \_species\_ and a better representation on the whole of the

European flora--this being clearly due to the large influx of species it

has received from the Antarctic Islands, in addition to those which have

entered it by way of Asia. The greater distance of South Africa even now

from any of these islands, and the much deeper sea to the south of the

African continent, than in the case of Tasmania and New Zealand, indicating

a smaller recent extension southward, is all quite in harmony with the

facts of distribution of the northern flora above referred to.

\_Supposed Connection of South Africa and Australia.\_--There remains,

however, the small amount of direct affinity between the vegetation of

South Africa and that of Australia, New Zealand, and Temperate South

America, consisting in all of fifteen genera, five of which are confined to

Australia and South Africa, while several natural orders are better

represented in these two countries than in any other part of the world.

This resemblance has been supposed to imply some former land-connection of

all the great southern lands, but it appears to me that any such

supposition is wholly unnecessary. The differences between the faunas and

floras of these countries are too great and too radical to render it

possible that any such connection should have existed except at a very

remote period. But if we have to go back so far for an explanation, a much

simpler one presents itself, and one more in accordance with what we have

learnt of the general permanence of deep oceans and the great changes that

have taken place {526} in the distribution of all forms of life. Just as we

explain the presence of marsupials in Australia and America and of

CentetidÃ¦ in Madagascar and the Antilles, by the preservation in these

localities of remnants of once wide-spread types, so we should prefer to

consider the few genera common to Australia and South Africa as remnants of

an ancient vegetation, once spread over the northern hemisphere, driven

southward by the pressure of more specialised types, and now finding a

refuge in these two widely separated southern lands. It is suggestive of

such an explanation that these genera are either of very ancient groups--as

Conifers and Cycads--or plants of low organisation as the RestiaceÃ¦--or of

world-wide distribution, as MelanthaceÃ¦.

\_The Endemic Genera of Plants in New Zealand.\_--Returning now to the New

Zealand flora, with which we are more especially concerned, there only

remains to be considered the peculiar or endemic genera which characterise

it. These are thirty-two in number, and are mostly very isolated. A few

have affinities with Arctic groups, others with Himalayan, or Australian

genera; several are tropical forms, but the majority appear to be

altogether peculiar types of world-wide groups--as LeguminosÃ¦, SaxifrageÃ¦,

CompositÃ¦, OrchideÃ¦, &c. We must evidently trace back these peculiar forms

to the earliest immigrants, either from the north or from the south; and

the great antiquity we are obliged to give to New Zealand--an antiquity

supported by every feature in its fauna and flora, no less than by its

geological structure, and its extinct forms of life[143]--affords ample

time for the changes in the general distribution of plants, and for those

due to isolation and modification under {527} the influence of changed

conditions, which are manifested by the extreme peculiarity of many of

these interesting endemic forms.

\_The Absence of Southern Types from the Northern Hemisphere.\_--We have now

only to notice the singular want of reciprocity in the migrations of

northern and southern types of vegetation. In return for the vast number of

European plants which have reached Australia, not one single Australian

plant has entered any part of the north temperate zone, and the same may be

said of the typical southern vegetation in general, whether developed in

the Antarctic lands, New Zealand, South America, or South Africa. The

furthest northern outliers of the southern flora are a few genera of

Antarctic type on the Bornean Alps; the genus AcÃ¦na which has a species in

California; two representatives of the Australian flora--Casuarina and

Stylidium, in the peninsula of India; while China and the Philippines have

two strictly Australian genera of OrchideÃ¦--Microtis and Thelymitra, as

well as a Restiaceous genus. Several distinct causes appear to have

combined to produce this curious inability of the southern flora to make

its way into the northern hemisphere. The primary cause is, no doubt, the

totally different distribution of land in the two hemispheres, so that in

the south there is the minimum of land in the colder parts of the temperate

zone and in the north the maximum. This is well shown by the fact that on

the parallel of Lat. 50Â° N. we pass over 240Â° of land or shallow sea, while

on the same parallel of south latitude we have only 4Â°, where we cross the

southern part of Patagonia. Again the three most important south temperate

land-areas--South Temperate America, South Africa, and Australia--are

widely separated from each other, and have in all probability always been

so; whereas the whole of the north temperate lands are practically

continuous. It follows that, instead of the enormous northern area, in

which highly organised and dominant groups of plants have been developed

gifted with great colonising and aggressive powers, we have in the south

three comparatively small and detached areas, in which rich floras have

been developed with \_special\_ {528} adaptations to soil, climate, and

organic environment, but comparatively impotent and inferior beyond their

own domain.

Another circumstance which makes the contest between the northern and

southern forms still more unequal, is the much greater hardiness of the

former, from having been developed in a colder region, and one where alpine

and arctic conditions extensively prevail; whereas the southern floras have

been mainly developed in mild regions to which they have been altogether

confined. While the northern plants have been driven north or south by each

succeeding change of climate, the southern species have undergone

comparatively slight changes of this nature, owing to the areas they occupy

being unconnected with the ice-bearing Antarctic continent. It follows,

that whereas the northern plants find in all these southern lands a milder

and more equable climate than that to which they have been accustomed, and

are thus often able to grow and flourish even more vigorously than in their

native land, the southern plants would find in almost every part of Europe,

North America or Northern Asia, a more severe and less equable climate,

with winters that usually prove fatal to them even under cultivation. These

causes, taken separately, are very powerful, but when combined they must, I

think, be held to be amply sufficient to explain why examples of the

typical southern vegetation are almost unknown in the north temperate zone,

while a very few of them have extended so far as the northern tropic.[144]

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\_Concluding Remarks on the Last Two Chapters.\_--Our inquiry into the

external relations and probable origin of the fauna and flora of New

Zealand, has thus led us on to a general theory as to the cause of the

peculiar biological relations between the northern and the southern

hemispheres; and no better or more typical example could be found of the

wide range and great interest of the study of the geographical distribution

of animals and plants.

The solution which has here been given of one of the most difficult of this

class of problems, has been rendered possible solely by the knowledge very

recently obtained of the form of the sea-bottom in the southern ocean, and

of the geological structure of the great Australian continent. Without this

knowledge we should have nothing but a series of guesses or probabilities

on which to found our hypothetical explanation, which we have now been able

to build up on a solid foundation of fact. The complete separation of East

from West Australia during a portion of the Cretaceous and Tertiary

periods, could never have been guessed till it was established by the

laborious explorations of the Australian geologists; while the hypothesis

of a comparatively shallow sea, uniting New Zealand by a long route with

tropical Australia, while a profoundly deep ocean always separated it from

temperate Australia, would have been rejected as too improbable a

supposition for the foundation of even the most enticing theory. Yet it is

mainly by means of these two facts, that we are enabled to give an adequate

explanation of the strange anomalies in the flora of Australia and its

relation to that of New Zealand.

In the more general explanation of the relations of the various northern

and southern floras, I have shown what an important aid to any such

explanation is the theory of repeated changes of climate, not necessarily

of great amount, given in Chapters VIII. and IX.; while the whole

discussion justifies the importance attached to the theory of the general

permanence of continents and oceans, as demonstrated in Chapter VI., since

any rational explanation based upon facts (as opposed to mere unsupported

{530} conjecture) must take such general permanence as a starting-point.

The whole inquiry into the phenomena presented by islands, which forms the

main subject of the present volume has, I think, shown that this theory

does afford a firm foundation for the discussion of questions of

distribution and dispersal; and that by its aid, combined with a clear

perception of the wonderful powers of dispersion and modification in the

organic world when long periods are considered, the most difficult problems

connected with this subject cease to be insoluble.

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CHAPTER XXIV

SUMMARY AND CONCLUSION

The Present Volume is the Development and Application of a

Theory--Statement of the Biological and Physical Causes of

Dispersal--Investigation of the Facts of Dispersal--of the Means of

Dispersal--of Geographical Changes Affecting Dispersal--of Climatal

Changes Affecting Dispersal--The Glacial Epoch and its Causes--Alleged

Ancient Glacial Epochs--Warm Polar Climates and their

Causes--Conclusions as to Geological Climates--How far Different from

those of Mr. Croll--Supposed Limitations of Geological Time--Time Amply

Sufficient both for Geological and Biological Development--Insular

Faunas and Floras--The North Atlantic Islands--The Galapagos--St.

Helena and the Sandwich Islands--Great Britain as a Recent Continental

Island--Borneo and Java--Japan and Formosa--Madagascar as an Ancient

Continental Island--Celebes and New Zealand as Anomalous Islands--The

Flora of New Zealand and its Origin--The European Element in the South

Temperate Floras--Concluding Remarks.

The present volume has gone over a very wide field both of facts and

theories, and it will be well to recall these to the reader's attention and

point out their connection with each other, in a concluding chapter. I hope

to be able to show that, although at first sight somewhat fragmentary and

disconnected, this work is really the development of a clear and definite

theory, and its application to the solution of a number of biological

problems. That theory is, briefly, that the distribution of the various

species and groups of living things over the earth's surface, and their

aggregation in definite assemblages in certain areas, is the {532} direct

result and outcome of a complex set of causes, which may be grouped as

"biological" and "physical." The biological causes are mainly of two

kinds--firstly, the constant tendency of all organisms to increase in

numbers and to occupy a wider area, and their various powers of dispersion

and migration through which, when unchecked, they are enabled to spread

widely over the globe; and, secondly, those laws of evolution and

extinction which determine the manner in which groups of organisms arise

and grow, reach their maximum, and then dwindle away, often breaking up

into separate portions which long survive in very remote regions. The

physical causes are also mainly of two kinds. We have, first, the

geographical changes which at one time isolate a whole fauna and flora, at

another time lead to their dispersal and intermixture with adjacent faunas

and floras--and it was here important to ascertain and define the exact

nature and extent of these changes, and to determine the question of the

general stability or instability of continents and oceans; in the second

place, it was necessary to determine the exact nature, extent and frequency

of the changes of climate which have occurred in various parts of the

earth,--because such changes are among the most powerful agents in causing

the dispersal and extinction of plants and animals. Hence the importance

attached to the question of geological climates and their causes, which

have been here investigated at some length with the aid of the most recent

researches of geologists, physicists, and explorers. These various

inquiries led on to an investigation of the mode of formation of stratified

deposits, with a view to fix within some limits their probable age; and

also to an estimate of the probable rate of development of the organic

world; and both these processes are shown to involve, so far as we can

judge, periods of time less vast than have generally been thought

necessary.

The numerous facts and theories established in the First Part of the work

are then applied to explain the phenomena presented by the floras and

faunas of the chief islands of the globe, which are classified, in

accordance with their physical origin, in three groups or classes, each

{533} of which are shown to exhibit certain well-marked biological

features.

Having thus shown that the work is a connected whole, founded on the

principle of tracing out the more recondite causes of the distribution of

organisms, we will briefly indicate the scope and object of the several

chapters, by means of which this general conception has been carried out.

Beginning with simple and familiar facts relating to British and European

quadrupeds and birds, I have defined and shown the exact character of

"areas of distribution," as applied to species, genera, and families, and

have illustrated the subject by maps showing the peculiarities of

distribution of some well-known groups of birds. Taking then our British

mammals and land-birds, I follow them over the whole area they inhabit, and

thus obtain a foundation for the establishment of "zoological regions," and

a clear insight into their character as distinct from the usual

geographical divisions of the globe.

The facts thus far established are then shown to be necessary results of

the "law of evolution." The nature and amount of "variation" is exhibited

by a number of curious examples; the origin, growth, and decay of species

and genera are traced, and all the interesting phenomena of isolated groups

and discontinuous generic and specific areas are shown to follow as logical

consequences.

The next subject investigated is the means by which the various groups of

animals are enabled to overcome the natural barriers which often seem to

limit them to very restricted areas, how far those barriers are themselves

liable to be altered or abolished, and what is the exact nature and amount

of the changes of sea and land which our earth has undergone in past times.

This latter part of the inquiry is shown to be the most important as it is

the most fundamental; and as it is still a subject of controversy, and many

erroneous views prevail in regard to it, it is discussed at some length.

Several distinct classes of evidence are adduced to prove that the grand

features of our globe--the position of the great oceans {534} and the chief

land-areas--have remained, on the whole, unchanged throughout geological

time. Our continents are shown to be built up mainly of "shore-deposits";

and even the chalk, which is so often said to be the exact equivalent of

the "globigerina ooze" now forming in mid-Atlantic, is shown to be a

comparatively shallow-water deposit formed in inland seas, or in the

immediate vicinity of land. The general stability of continents has,

however, been accompanied by constant changes of form, and insular

conditions have prevailed over every part in succession; and the effect of

such changes on the distribution of organisms is pointed out.

We then approach the consideration of another set of changes--those of

climate--which have probably been agents of the first importance in

modifying the specific forms as well as the distribution of animals. Here

again we find ourselves in the midst of fierce controversies. The

occurrence of a recent glacial epoch of great severity in the northern

hemisphere is now universally admitted, but the causes which brought it on

are matter of dispute. But unless we can arrive at these causes, as well as

at those which produced the equally well demonstrated mild climate in the

Arctic regions, we shall be quite unable to determine the nature and amount

of the changes of climate which have occurred throughout past ages, and

shall thus be left without a most important clue to the explanation of many

of the anomalies in the distribution of animals and plants.

I have therefore devoted three chapters to a full investigation of this

question. I have first given such a sketch of the most salient facts as to

render the phenomena of the glacial epoch clear and intelligible. I then

review the various suggested explanations, and, taking up the two which

alone seem tenable, I endeavour to determine the true principles of each.

While adopting generally Mr. Croll's views as to the causes of the "glacial

epoch," I have introduced certain limitations and modifications. I have

pointed out, I believe, more clearly than has hitherto been done, the very

different effects on climate of water in the liquid and in the solid state;

and I have {535} shown, by a variety of evidence, that without high land

there can be no permanent snow and ice. From these facts and principles the

very important conclusion is reached, that the alternate phases of

precession--causing the winter of each hemisphere to be in \_aphelion\_ and

\_perihelion\_ each 10,500 years--would produce a complete change of climate

only where a country was \_partially\_ snow-clad; while, whenever a large

area became almost \_wholly\_ buried in snow and ice--as was certainly the

case with Northern Europe and America during the glacial epoch--then the

glacial conditions would be continued and perhaps even intensified when the

sun approached nearest to the earth in winter, instead of there being at

that time, as Mr. Croll maintains, an almost perpetual spring. This

important result is supported by reference to the existing differences

between the climates of the northern and southern hemispheres, and by what

is known to have occurred during the last glacial epoch; and it is shown to

be in complete harmony with the geological evidence as to interglacial mild

periods.

Discussing next the evidence for glacial epochs in earlier times, it is

shown that Mr. Croll's views are opposed by a vast body of facts, and that

the geological evidence leads irresistibly to the conclusion that during a

large portion of the Secondary and Tertiary periods, uninterrupted warm

climates prevailed in the north temperate zone, and so far ameliorated the

climate of the Arctic regions as to admit of the growth of a luxuriant

vegetation in the highest latitudes yet explored. The geographical

condition of the northern hemisphere at these periods is then investigated,

and it is shown to have been probably such as to admit the warm tropical

waters freely to penetrate the land, and to reach the Arctic seas by

several channels; and, adopting Mr. Croll's calculations as to the enormous

quantity of heat that would thus be conveyed northwards, it is maintained

that the mild Arctic climates are amply accounted for. With such favourable

geographical conditions, it is shown, that changes of excentricity and of

the phases of precession would have no other effect than to cause greater

differences {536} of temperature between summer and winter; but, wherever

there was a considerable extent of very lofty mountains the snow-line would

be lowered, and the snow-collecting area being thus largely increased a

considerable amount of local glaciation might result. Thus may be explained

the presence of enormous ice-borne rocks in Eocene and Miocene times in

Central Europe, while at the very same period all the surrounding country

enjoyed a tropical or sub-tropical climate.

The general conclusion is thus reached, that geographical conditions are

the essential causes of great changes of climate, and that the radically

different distribution of land and sea in the northern and southern

hemispheres has generally led to great diversity of climate in the Arctic

and Antarctic regions. The form and arrangement of the continents is shown

to be such as to favour the transfer of warm oceanic currents to the north

far in excess of those which move towards the south, and whenever these

currents had free passage \_through\_ the northern land-masses to the polar

area, a mild climate must have prevailed over the whole northern

hemisphere. It is only in very recent times that the great northern

continents have become so completely consolidated as they now are, thus

shutting out the warm water from their interiors, and rendering possible a

wide-spread and intense glacial epoch. But this great climatal change was

actually brought about by the high excentricity which occurred about

200,000 years ago; and it is doubtful if a similar glaciation in equally

low latitudes could be produced by means of any such geographical

combinations as actually occur, without the concurrence of a high

excentricity.

A survey of the present condition of the earth supports this view, for

though we have enormous mountain ranges in every latitude, there is no

glaciated country south of Greenland in N. Lat. 61Â°. But directly we go

back a very short period, we find the superficial evidences of glaciation

to an enormous extent over three-fourths of the globe. In the Alps and

Pyrenees, in the British Isles and Scandinavia, in Spain and the Atlas, in

the Caucasus {537} and the Himalayas, in Eastern North America and west of

the Rocky Mountains, in the Andes of South Temperate America, in South

Africa, and in New Zealand, huge moraines and other unmistakable ice-marks

attest the universal descent of the snow-line for several thousand feet

below its present level. If we reject the influence of high excentricity as

the cause of this almost universal glaciation, we must postulate a general

elevation of \_all\_ these mountains about the same time, geologically

speaking--for the general similarity in the state of preservation of the

ice-marks and the known activity of denudation as a destroying agent,

forbid the idea that they belong to widely separated epochs. It has,

indeed, been suggested, that denudation alone has lowered these mountains

so much during the post-tertiary epoch, that they were previously of

sufficient height to account for the glaciation of all of them; but this

hardly needs refutation, for it is clear that denudation could not at the

same time have removed some thousands of feet of rock from many hundreds of

square miles of lofty snow-collecting plateaus, and yet have left moraines,

and blocks, and even glacial striÃ¦, undisturbed and uneffaced on the slopes

and in the valleys of these same mountains.

The theory of geological climates set forth in this volume, while founded

on Mr. Croll's researches, differs from all that have yet been made public,

in clearly tracing out the comparative influence of geographical and

astronomical revolutions, showing that, while the former have been the

chief, if not the exclusive, causes of the long-continued mild climates of

the Arctic regions, the concurrence of the latter has been essential to the

production of glacial epochs in the temperate zones, as well as of those

local glaciations in low latitudes, of which there is such an abundance of

evidence.

The next question discussed is that of geological time as bearing on the

development of the organic world. The periods of time usually demanded by

geologists have been very great, and it was often assumed that there was no

occasion to limit them. But the theory of development demands far more; for

the earliest fossiliferous rocks {538} prove the existence of many and

varied forms of life which require unrecorded ages for their

development--ages probably far longer than those which have elapsed from

that period to the present day. The physicists, however, deny that any such

indefinitely long periods are available. The sun is ever losing heat far

more rapidly than it can be renewed from any known or conceivable source.

The earth is a cooling body, and must once have been too hot to support

life; while the friction of the tides is checking the earth's rotation, and

this cannot have gone on indefinitely without making our day much longer

than it is. A limit is therefore placed to the age of the habitable earth,

and it has been thought that the time so allowed is not sufficient for the

long processes of geological change and organic development. It is

therefore important to inquire whether these processes are either of them

so excessively slow as has been supposed, and I devote a chapter to the

inquiry.

Geologists have measured with some accuracy the maximum thickness of all

the known sedimentary rocks. The rate of denudation has also been recently

measured by a method which, if not precise, at all events gives results of

the right order of magnitude and which err on the side of being too slow

rather than too fast. If, then, the \_maximum\_ thickness of the \_known\_

sedimentary rocks is taken to represent the \_average\_ thickness of \_all\_

the sedimentary rocks, and we also know the \_amount\_ of sediment carried to

the sea or lakes, and the \_area\_ over which that sediment is spread, we

have a means of calculating the \_time\_ required for the building up of all

the sedimentary rocks of the geological system. I have here inquired how

far the above suppositions are correct, or on which side they probably err;

and the conclusion arrived at is, that the time required is very much less

than has hitherto been supposed.

Another estimate is afforded by the date of the last glacial epoch if

coincident with the last period of high excentricity, while the Alpine

glaciation of the Miocene period is assumed to have been caused by the next

earlier phase of very high excentricity. Taking these as data, the {539}

proportionate change of the species of mollusca affords a means of arriving

at the whole lapse of time represented by the fossiliferous rocks; and

these two estimates agree in the \_order\_ of their magnitudes.

It is then argued that the changes of climate every 10,500 years during the

numerous periods of high excentricity have acted as a motive power in

hastening on both geological and biological change. By raising and lowering

the snow-line in all mountain ranges it has caused increased denudation;

while the same changes have caused much migration and disturbance in the

organic world, and have thus tended to the more rapid modification of

species. The present epoch being a period of very low excentricity, the

earth is in a phase of \_exceptional stability\_ both physical and organic;

and it is from this period of exceptional stability that our notions of the

very slow rate of change have been derived.

The conclusion is, on the whole, that the periods allowed by physicists are

not only far in excess of such as are required for geological and organic

change, but that they allow ample margin for a lapse of time anterior to

the deposit of the earliest fossiliferous rocks several times longer than

the time which has elapsed since their deposit to the present day.

Having thus laid the foundation for a scientific interpretation of the

phenomena of distribution, we proceed to the Second Part of our work--the

discussion of a series of typical Insular Faunas and Floras with a view to

explain the interesting phenomena they present. Taking first two North

Atlantic groups--the Azores and Bermuda--it is shown how important an agent

in the dispersal of most animals and plants is a stormy atmosphere.

Although 900 and 700 miles respectively from the nearest continents, their

productions are very largely identical with those of Europe and America;

and, what is more important, fresh arrivals of birds, insects, and plants,

are now taking place almost annually. These islands afford, therefore, test

examples of the great dispersive powers of certain groups of organisms, and

thus serve as a basis on which to found our explanations of many anomalies

of distribution. Passing {540} on to the Galapagos we have a group less

distant from a continent and of larger area, yet, owing to special

conditions, of which the comparatively stormless equatorial atmosphere is

the most important, exhibiting far more speciality in its productions than

the more distant Azores. Still, however, its fauna and flora are as

unmistakably derived from the American continent as those of the Azores are

from the European.

We next take St. Helena and the Sandwich Islands, both wonderfully isolated

in the midst of vast oceans, and no longer exhibiting in their productions

an exclusive affinity to one continent. Here we have to recognise the

results of immense antiquity, and of those changes of geography, of

climate, and in the general distribution of organisms which we know have

occurred in former geological epochs, and whose causes and consequences we

have discussed in the first part of our volume. This concludes our review

of the Oceanic Islands.

Coming now to Continental Islands we consider first those of most recent

origin and offering the simplest phenomena; and begin with the British

Isles as affording the best example of very recent and well known

Continental Islands. Reviewing the interesting past history of Britain, we

show why it is comparatively poor in species and why this poverty is still

greater in Ireland. By a careful examination of its fauna and flora it is

then shown that the British Isles are not so completely identical,

biologically, with the continent as has been supposed. A considerable

amount of speciality is shown to exist, and that this speciality is real

and not apparent is supported by the fact, that small outlying islands,

such as the Isle of Man, the Shetland Isles, Lundy Island, and the Isle of

Wight, all possess certain species or varieties not found elsewhere.

Borneo and Java are next taken, as illustrations of tropical islands which

may be not more ancient than Britain, but which, owing to their much larger

area, greater distance from the continent, and the extreme richness of the

equatorial fauna and flora, possess a large proportion of peculiar species,

though these are in general very closely allied to those of the adjacent

parts of Asia. The {541} preliminary studies we have made enable us to

afford a simpler and more definite interpretation of the peculiar relations

of Java to the continent and its differences from Borneo and Sumatra, than

was given in my former work (\_The Geographical Distribution of Animals\_).

Japan and Formosa are next taken, as examples of islands which are

decidedly somewhat more ancient than those previously considered, and which

present a number of very interesting phenomena, especially in their

relations to each other, and to remote rather than to adjacent parts of the

Asiatic continent.

We now pass to the group of Ancient Continental Islands, of which

Madagascar is the most typical example. It is surrounded by a number of

smaller islands which may be termed its satellites since they partake of

many of its peculiarities; though some of these--as the Comoros and

Seychelles--may be considered continental, while others--as Bourbon,

Mauritius, and Rodriguez--are decidedly oceanic. In order to understand the

peculiarities of the Madagascar fauna we have to consider the past history

of the African and Asiatic continents, which it is shown are such as to

account for all the main peculiarities of the fauna of these islands

without having recourse to the hypothesis of a now-submerged Lemurian

continent. Considerable evidence is further adduced to show that "Lemuria"

is a myth, since not only is its existence unnecessary, but it can be

proved that it would not explain the actual facts of distribution. The

origin of the interesting Mascarene wingless birds is discussed, and the

main peculiarities of the remarkable flora of Madagascar and the Mascarene

islands pointed out; while it is shown that all these phenomena are to be

explained on the general principles of the permanence of the great oceans

and the comparatively slight fluctuations of the land area, and by taking

account of established palÃ¦ontological facts.

There remain two other islands--Celebes and New Zealand--which are classed

as "anomalous," the one because it is almost impossible to place it in any

of the six zoological regions, or determine whether it has ever been

actually joined to a continent--the other because it {542} combines the

characteristics of continental and oceanic islands.

The peculiarities of the Celebesian fauna have already been dwelt upon in

several previous works, but they are so remarkable and so unique that they

cannot be omitted in a treatise on "Insular Faunas"; and here, as in the

case of Borneo and Java, fuller consideration and the application of the

general principles laid down in our First Part, lead to a solution of the

problem at once more simple and more satisfactory than any which have been

previously proposed. I now look upon Celebes as an outlying portion of the

great Asiatic continent of Miocene times, which either by submergence or

some other cause had lost the greater portion of its animal inhabitants,

and since then has remained more or less completely isolated from every

other land. It has thus preserved a fragment of a very ancient fauna along

with a number of later types which have reached it from surrounding islands

by the ordinary means of dispersal. This sufficiently explains all the

peculiar \_affinities\_ of its animals, though the peculiar and distinctive

\_characters\_ of some of them remain as mysterious as ever.

New Zealand is shown to be so completely continental in its geological

structure, and its numerous wingless birds so clearly imply a former

connection with some other land (as do its numerous lizards and its

remarkable reptile, the Hatteria), that the total absence of indigenous

land-mammalia was hardly to be expected. Some attention is therefore given

to the curious animal which has been seen but never captured, and this is

shown to be probably identical with an animal referred to by Captain Cook.

The more accurate knowledge which has recently been obtained of the sea

bottom around New Zealand enables us to determine that the former

connection of that island with Australia was towards the north, and this is

found to agree well with many of the peculiarities of its fauna.

The flora of New Zealand and that of Australia are now both so well known,

and they present so many peculiarities, and relations of so anomalous a

character, {543} as to present in Sir Joseph Hooker's opinion an almost

insoluble problem. Much additional information on the physical and

geological history of these two countries has, however, been obtained since

the appearance of Sir Joseph Hooker's works, and I therefore determined to

apply to them the same method of discussion and treatment which has been

usually successful with similar problems in the case of animals. The fact

above noted, that New Zealand was connected with Australia in its northern

and tropical portion only, of itself affords a clue to one portion of the

specialities of the New Zealand flora--the presence of an unusual number of

tropical families and genera, while the temperate forms consist mainly of

species either identical with those found in Australia or closely allied to

them. But a still more important clue is obtained in the geological

structure of Australia itself, which is shown to have been for long periods

divided into an eastern and a western island, in the latter of which the

highly peculiar flora of temperate Australia was developed. This is found

to explain with great exactness the remarkable absence from New Zealand of

all the most abundant and characteristic Australian genera, both of plants

and of animals, since these existed at that time only in the \_western\_

island, while New Zealand was in connection with the \_eastern\_ island alone

and with the tropical portion of it. From these geological and physical

facts, and the known powers of dispersal of plants, all the main features,

and many of the detailed peculiarities of the New Zealand flora are shown

necessarily to result.

Our last chapter is devoted to a wider, and if possible more interesting

subject--the origin of the European element in the floras of New Zealand

and Australia, and also in those of South America and South Africa. This is

so especially a botanical question, that it was with some diffidence I

entered upon it, yet it arose so naturally from the study of the New

Zealand and Australian floras, and seemed to have so much light thrown upon

it by our preliminary studies as to changes of climate and the causes which

have favoured the distribution of plants, that I felt my work would be

incomplete without a consideration of {544} it. The subject will be so

fresh in the reader's mind that a complete summary of it is unnecessary. I

venture to think, however, that I have shown, not only the several routes

by which the northern plants have reached the various southern lands, but

have pointed out the special aids to their migration, and the motive power

which has urged them on.

In this discussion, if nowhere else, will be found a complete justification

of that lengthy investigation of the exact nature of past changes of

climate, which to some readers may have seemed unnecessary and unsuited to

such a work as the present. Without the clear and definite conclusions

arrived at by that discussion, and those equally important views as to the

permanence of the great features of the earth's surface, and the wonderful

dispersive powers of plants which have been so frequently brought before us

in our studies of insular floras, I should not have ventured to attack the

wide and difficult problem of the northern element in southern floras.

In concluding a work dealing with subjects which have occupied my attention

for many years, I trust that the reader who has followed me throughout will

be imbued with the conviction that ever presses upon myself, of the

complete interdependence of organic and inorganic nature. Not only does the

marvellous structure of each organised being involve the whole past history

of the earth, but such apparently unimportant facts as the presence of

certain types of plants or animals in one island rather than in another,

are now shown to be dependent on the long series of past geological

changes--on those marvellous astronomical revolutions which cause a

periodic variation of terrestrial climates--on the apparently fortuitous

action of storms and currents in the conveyance of germs--and on the

endlessly varied actions and reactions of organised beings on each other.

And although these various causes are far too complex in their combined

action to enable us to follow them out in the case of any one species, yet

their broad results are clearly recognisable; and we are thus encouraged to

study more completely every detail and {545} every anomaly in the

distribution of living things, in the firm conviction that by so doing we

shall obtain a fuller and clearer insight into the course of nature, and

with increased confidence that the "mighty maze" of Being we see everywhere

around us is "not without a plan."

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THE END

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\* \* \* \* \*

[1] A small number of species belonging to the West Indies are found in the

extreme southern portion of the Florida Peninsula.

[2] I cannot avoid here referring to the enormous waste of labour and money

with comparatively scanty and unimportant results to natural history of

most of the great scientific voyages of the various civilized governments

during the present century. All these expeditions combined have done far

less than private collectors in making known the products of remote lands

and islands. They have brought home fragmentary collections, made in widely

scattered localities, and these have been usually described in huge folios

or quartos, whose value is often in inverse proportion to their bulk and

cost. The same species have been collected again and again, often described

several times over under new names, and not unfrequently stated to be from

places they never inhabited. The result of this wretched system is that the

productions of some of the most frequently visited and most interesting

islands on the globe are still very imperfectly known, while their native

plants and animals are being yearly exterminated, and this is the case even

with countries under the rule or protection of European governments. Such

are the Sandwich Islands, Tahiti, the Marquesas, the Philippine Islands,

and a host of smaller ones; while Bourbon and Mauritius, St. Helena, and

several others, have only been adequately explored after an important

portion of their productions has been destroyed by cultivation or the

reckless introduction of goats and pigs. The employment in each of our

possessions, and those of other European powers, of a resident naturalist

at a very small annual expense, would have done more for the advancement of

knowledge in this direction than all the expensive expeditions that have

again and again circumnavigated the globe.

[3] The general facts of PalÃ¦ontology, as bearing on the migrations of

animal groups, are summarised in my \_Geographical Distribution of Animals\_,

Vol. I. Chapters VI., VII., and VIII.

[4] Since these lines were written, a fine series of specimens of this rare

humming-bird has been obtained from the same locality. (See \_Proc. Zool.

Soc.\_ 1881, pp. 827-834.)

[5] Many of these large genera are now subdivided, the divisions being

sometimes termed genera, sometimes sub-genera.

[6] The PalÃ¦arctic region includes temperate Asia and Europe, as will be

explained in the next chapter.

[7] The following list of the genera of reptiles and amphibia peculiar to

the PalÃ¦arctic Region has been furnished me by Mr. G. A. Boulenger, of the

British Museum:--

SNAKES. FROGS AND TOADS.

\_Achalinus\_--China, Japan. \_Pelobates\_--Eur., S.W. Asia.

\_Coelopeltis\_--S. Eur., N. Af., \_Pelodytes\_--W. Europe.

S.W. Asia. \_Discoglossus\_--S. Eur., N.W. Af.

\_Macroprotodon\_--S. Eur., N. Af. \_Bombinator\_--Eur., Temp. Asia.

\_Taphrometopon\_--Cent. Asia. \_Alytus\_--Cent. and W. Eur.

LIZARDS. NEWTS.

\_Phrynocephalus\_--Cent. and S.W. \_Salamandra\_--Eur., N. Af., S.W.

Asia. Asia.

\_Anguis\_--Europe, W. Asia. \_Chioglossa\_--Spain and Portugal.

\_Blanus\_--S.W. Eur., N.W. Africa, \_Salamandrina\_--Italy.

S.W. Asia. \_Pachytriton\_--East Thibet.

\_Trogonophis\_--N.W. Africa. \_Hynobius\_--China and Japan.

\_Lacerta\_--Eur., Temp. Asia, N. \_Geomolge\_--E. Manchuria.

Africa (one sp. in \_Onychodactylus\_--Japan.

W. Af.). \_Salamandrella\_--Siberia.

\_Psammodromus\_--S.W. Eur., N.W. \_Ranidens\_--Siberia.

Africa. \_Batrachyperus\_--East Thibet.

\_Algiroides\_--S. Eur. \_Myalobatrachus\_--China, Japan.

\_Proteus\_--Caverns of S. Austria.

[8] Remains of the dingo have been found fossil in Pleistocene deposits but

the antiquity of man in Australia is not known. It is not, however,

improbable that it may be as great as in Europe. My friend A. C. Swinton,

Esq., while working in the then almost unknown gold-field of Maryborough,

Victoria, in January, 1855, found a fragment of a well-formed stone axe

resting on the metamorphic schistose bed-rock about five feet beneath the

surface. It was overlain by the compact gravel drift called by the miners

"cement," and by an included layer of hard iron-stained sandstone. The

fragment is about an inch and three-eighths wide and the same length, and

is of very hard fine-grained black basalt. One side is ground to a very

smooth and regular surface, terminating in a well-formed cutting edge more

than an inch long, the return face of the cutting part being about a

quarter of an inch wide. The other side is a broken surface. The weapon

appears to have been an axe or tomahawk closely resembling that figured at

p. 335 of Lumholtz's \_Among Cannibals\_, from Central Queensland. The

fragment was discovered by Mr. Swinton and the late Mr. Mackworth Shore,

one of the discoverers of the gold-field, before any rush to it had taken

place, and it seems impossible to avoid the conclusion that it was formed

prior to the deposit of the gravel drift and iron-stained sandstone under

which it lay. This would indicate a great antiquity of man in Australia,

and would enable us to account for the fossilised remains of the dingo in

Pleistocene deposits as those of an animal introduced by man.

[9] These facts are taken from a memoir on \_The Mammals and Winter Birds of

Florida\_, by J. A. Allen; forming Vol. II., No. 3, of the Bulletin of the

Museum of Comparative Zoology at Harvard College, Cambridge, Massachusetts.

[10] The great variation in wild animals is more fully discussed and

illustrated in the author's \_Darwinism\_ (Chapter III.).

[11] See \_Ibis\_, 1879, p. 32.

[12] In Mr. Seebohm's latest work, \_Birds of the Japanese Empire\_ (1890),

he says, "Examples from North China are indistinguishable from those

obtained in Greece" (p. 82).

[13] \_Ibis\_, 1879, p. 40. In his \_Birds of the Japanese Empire\_ (1890), Mr.

Seebohm classes the Japanese and European forms as \_E. schoeniclus\_, and

thinks that their range is probably continuous across the two continents.

[14] Lyell's \_Principles of Geology\_, ii., p. 369.

[15] Mr. Darwin found that the large \_Helix pomatia\_ lived after immersion

in sea-water for twenty days. It is hardly likely that this is the extreme

limit of their powers of endurance, but even this would allow of their

being floated many hundred miles at a stretch, and if we suppose the shell

to be partially protected in the crevice of a log of wood, and to be thus

out of water in calm weather, the distance might extend to a thousand miles

or more. The eggs of fresh-water mollusca, as well as the young animals,

are known to attach themselves to the feet of aquatic birds, and this is

probably the most efficient cause of their very wide diffusion.

[16] \_Principles of Geology\_, 11th Ed., Vol. I., p. 258.

[17] On Limestone as an Index of Geological Time.

[18] In his \_Preliminary Report on Oceanic Deposit\_, Mr. Murray says:--"It

has been found that the deposits taking place near continents and islands

have received their chief characteristics from the presence of the \_debris\_

of adjacent lands. In some cases these deposits extend to a distance of

over 150 miles from the coast." (\_Proceedings of the Royal Society\_, Vol.

XXIV. p. 519.)

"The materials in suspension appear to be almost entirely deposited within

200 miles of the land." (\_Proceedings of the Royal Society of Edinburgh\_,

1876-77, p. 253.)

[19] \_Geographical Evolution. (Proceedings of the Royal Geographical

Society.\_ 1879, p. 426.)

[20] Professor Dana was, I believe, the first to point out that the regions

which, after long undergoing subsidence and accumulating vast piles of

sedimentary deposit have been elevated into mountain ranges, thereby become

stiff and unyielding, and that the next depression and subsequent upheaval

will be situated on one or the other sides of it; and he has shown that, in

North America, this is the case with all the mountains of the successive

geological formations. Thus, depressions, and elevations of extreme

slowness but often of vast amount, have occurred successively in restricted

adjacent areas; and the effect has been to bring each portion in succession

beneath the ocean but always bordered on one or both sides by the remainder

of the continent, from the denudation of which the deposits are formed

which, on the subsequent upheaval, become mountain ranges. (\_Manual of

Geology\_, 2nd Ed., p. 751.)

[21] \_Nature\_, Vol. II., p. 297.

[22] Sir W. Thomson, \_Voyage of Challenger\_, Vol. II., p. 374.

[23] The following is the analysis of the chalk at Oahu:--

Carbonate of Lime 92.800 per cent.

Carbonate of Magnesia 2.385 ,,

Alumina 0.250 ,,

Oxide of Iron 0.543 ,,

Silica 0.750 ,,

Phosphoric Acid and Fluorine 2.113 ,,

Water and loss 1.148 ,,

This chalk consists simply of comminuted corals and shells of the reef. It

has been examined microscopically and found to be destitute of the minute

organisms abounding in the chalk of England. (\_Geology of the United States

Exploring Expedition\_, p. 150.) Mr. Guppy also found chalk-like coral

limestones containing 95 p.c. of carbonate of lime in the Solomon Islands.

The absence of \_GlobigerinÃ¦\_ is a local phenomenon. They are quite absent

in the Arafura Sea, and no \_Globigerina\_-ooze was found in any of the

enclosed seas of the Pacific, but with these exceptions the \_GlobigerinÃ¦\_

"are really found all over the bottom of the ocean." (Murray on Oceanic

Deposits--\_Proceedings of Royal Society\_, Vol. XXIV., p. 523.)

The above analysis shows a far closer resemblance to chalk than that of the

\_Globigerina\_-ooze of the Atlantic, four specimens of which given by Sir W.

Thomson (\_Voyage of the Challenger\_ Vol. II. Appendix, pp. 374-376, Nos. 9,

10, 11 and 12) from the mid-Atlantic, show the following proportions:--

Carbonate of Lime 43.93 to 79.17 per cent.

Carbonate of Magnesia 1.40 to 2.58 ,,

Alumina and Oxide of Iron 6.00? to 32.98 ,,

Silica 4.60 to 11.23 ,,

In addition to the above there is a quantity of insoluble residue

consisting of small particles of sanidine, augite, hornblende, and

magnetite, supposed to be the product of volcanic dust or ashes carried

either in the air or by ocean currents. This volcanic matter amounts to

from 4.60 to 8.33 per cent. of the \_Globigerina\_-ooze of the mid-Atlantic,

where it seems to be always present; and the small proportion of similar

matter in true chalk is another proof that its origin is different, and

that it was deposited far more rapidly than the oceanic ooze.

The following analysis of chalk by Mr. D. Forbes will show the difference

between the two formations:--

Grey Chalk, White Chalk,

\_Folkestone\_. \_Shoreham\_.

Carbonate of Lime 94.09 98.40

Carbonate of Magnesia 0.31 0.08

Alumina and Phosphoric Acid a trace 0.42

Chloride of Sodium 1.29 --

Insoluble dÃ©bris 3.61 1.10

(From \_Quarterly Journal of the Geological Society\_, Vol. XXVII.)

The large proportion of carbonate of lime, and the very small quantity of

silica, alumina, and insoluble \_dÃ©bris\_, at once distinguish true chalk

from the \_Globigerina\_-ooze of the deep ocean bed.

[24] Notes on Reticularian Rhizopoda; in \_Microscopical Journal\_, Vol.

XIX., New Series, p. 84.

[25] \_Proceedings of the Royal Society\_, Vol. XXIV. p. 532.

[26] See Presidential Address in Sect. D. of British Association at

Plymouth, 1877.

[27] \_Geological Magazine\_, 1871, p. 426.

[28] In his lecture on \_Geographical Evolution\_ (which was published after

the greater part of this chapter had been written) Sir Archibald Geikie

expresses views in complete accordance with those here advocated. He

says:--"The next long era, the Cretaceous, was more remarkable for slow

accumulation of rock under the sea than for the formation of new land.

During that time the Atlantic sent its waters across the whole of Europe

and into Asia. But they were probably nowhere more than a few hundred feet

deep over the site of our continent, even at their deepest part. Upon their

bottom there gathered a vast mass of calcareous mud, composed in great part

of foraminifera, corals, echinoderms, and molluscs. Our English chalk,

which ranges across the north of France, Belgium, Denmark, and the north of

Germany, represents a portion of the deposits of that sea-floor." The

weighty authority of the Director-General of the Geological Survey may

perhaps cause some geologists to modify their views as to the deep-sea

origin of chalk, who would have treated any arguments advanced by myself as

not worthy of consideration.

[29] \_Introduction and Succession of Vertebrate Life in America\_, by

Professor O. C. Marsh. Reprinted from the \_Popular Science Monthly\_, March,

April, 1878.

[30] \_Physical Geography and Geology of Great Britain\_, 5th Ed. p. 61.

[31] Of late it has been the custom to quote the so-called "ridge" down the

centre of the Atlantic as indicating an extensive ancient land. Even

Professor Judd at one time adopted this view, speaking of the great belt of

Tertiary volcanoes "which extended through Greenland, Iceland, the Faroe

Islands, the Hebrides, Ireland, Central France, the Iberian Peninsula, the

Azores, Madeira, Canaries, Cape de Verde Islands, Ascension, St. Helena,

and Tristan d'Acunha, and which constituted as shown by the recent

soundings of H.M.S. \_Challenger\_ a mountain-range, comparable in its

extent, elevation, and volcanic character with the Andes of South America"

(\_Geological Mag.\_ 1874, p. 71). On examining the diagram of the Atlantic

Ocean in the \_Challenger Reports\_, No. 7, a considerable part of this ridge

is found to be more than 1,900 fathoms deep, while the portion called the

"Connecting Ridge" seems to be due in part to the deposits carried out by

the River Amazon. In the neighbourhood of the Azores, St. Paul's Rocks,

Ascension, and Tristan d'Acunha are considerable areas varying from 1,200

to 1,500 fathoms deep, while the rest of the ridge is usually 1,800 or

1,900 fathoms. The shallower water is no doubt due to volcanic upheaval and

the accumulation of volcanic ejections, and there may be many other deeply

submerged old volcanoes on the ridge; but that it ever formed a chain of

mountains "comparable in elevation with the Andes," there seems not a

particle of evidence to prove. It is however probable that this ridge

indicates the former existence of some considerable Atlantic islands, which

may serve to explain the presence of a few identical genera, and even

species of plants and insects in Africa and South America, while the main

body of the fauna and flora of these two continents remains radically

distinct.

In my \_Darwinism\_ (pp. 344-5) I have given an additional argument founded

on the comparative height and area of land with the depth and area of

ocean, which seems to me to add considerably to the weight of the evidence

here submitted for the permanence of oceanic and continental areas.

[32] In a review of Mr. T. Mellard Reade's \_Chemical Denudation and

Geological Time\_, in \_Nature\_ (Oct. 2nd, 1879), the writer remarks as

follows:--"One of the funny notions of some scientific thinkers meets with

no favour from Mr. Reade, whose geological knowledge is practical as well

as theoretical. They consider that because the older rocks contain nothing

like the present red clays, &c., of the ocean floor, that the oceans have

always been in their present positions. Mr. Reade points out that the first

proposition is not yet proved, and the distribution of animals and plants

and the fact that the bulk of the strata on land are of marine origin are

opposed to the hypothesis." We must leave it to our readers to decide

whether the "notion" developed in this chapter is "funny," or whether such

hasty and superficial arguments as those here quoted from a "practical

geologist" have any value as against the different classes of facts, all

pointing to an opposite conclusion, which have now been briefly laid before

them, supported as they are by the expressed opinion of so weighty an

authority as Sir Archibald Geikie, who, in the lecture already quoted

says:--"From all this evidence we may legitimately conclude that the

present land of the globe, though formed in great measure of marine

formations, has never lain under the deep sea; but that its site must

always have been near land. Even its thick marine limestones are the

deposits of comparatively shallow water."

[33] \_Antiquity of Man\_, 4th Ed. pp. 340-348.

[34] \_The Great Ice Age and its Relation to the Antiquity of Man.\_ By James

Geikie, F.R.S. (Isbister and Co., 1874.)

[35] This view of the formation of "till" is that adopted, by Dr. Geikie,

and upheld by almost all the Scotch, Swiss, and Scandinavian geologists.

The objection however is made by many eminent English geologists, including

the late Mr. Searles V. Wood, Jun., that mud ground off the rocks cannot

remain beneath the ice, forming sheets of great thickness, because the

glacier cannot at the same time grind down solid rock and yet pass over the

surface of soft mud and loose stones. But this difficulty will disappear if

we consider the numerous fluctuations in the glacier with increasing size,

and the additions it must have been constantly receiving as the ice from

one valley after another joined together, and at last produced an ice-sheet

covering the whole country. The grinding power is the motion and pressure

of the ice, and the pressure will depend on its thickness. Now the points

of maximum thickness must have often changed their positions, and the

result would be that the matter ground out in one place would be forced

into another place where the pressure was less. If there were no lateral

escape for the mud, it would necessarily support the ice over it just as a

water-bed supports the person lying on it; and when there was little

drainage water, and the ice extended, say, twenty miles in every direction

from a given part of a valley where the ice was of less than the average

thickness, the mud would necessarily accumulate at this part simply because

there was no escape for it. Whenever the pressure all round any area was

greater than the pressure on that area, the \_dÃ©bris\_ of the surrounding

parts would be forced into it, and would even raise up the ice to give it

room. This is a necessary result of hydrostatic pressure. During this

process the superfluous water would no doubt escape through fissures or

pores of the ice, and would leave the mud and stones in that excessively

compressed and tenacious condition in which the "till" is found. The

unequal thickness and pressure of the ice above referred to would be a

necessary consequence of the inequalities in the valleys, now narrowing

into gorges, now opening out into wide plains, and again narrowed lower

down; and it is just in these openings in the valleys that the "till" is

said to be found, and also in the lowlands where an ice-sheet must have

extended for many miles in every direction. In these lowland valleys the

"till" is both thickest and most wide-spread, and this is what we might

expect. At first, when the glaciers from the mountains pushed out into

these valleys, they would grind out the surface beneath them into hollows,

and the drainage-water would carry away the \_dÃ©bris\_. But when they spread

all over the surface from sea to sea, and there was little or no drainage

water compared to the enormous area covered with ice, the great bulk of the

\_dÃ©bris\_ must have gathered under the ice wherever the pressure was least,

and the ice would necessarily rise as it accumulated. Some of the mud would

no doubt be forced out along lines of least resistance to the sea, but the

friction of the stone-charged "till" would be so enormous that it would be

impossible for any large part of it to be disposed of in this way.

[36] That the ice-sheet was continuous from Scotland to Ireland is proved

by the glacial phenomena in the Isle of Man, where "till" similar to that

in Scotland abounds, and rocks are found in it which must have come from

Cumberland and Scotland, as well as from the north of Ireland. This would

show that glaciers from each of these districts reached the Isle of Man,

where they met and flowed southwards down the Irish Sea. Ice-marks are

traced over the tops of the mountains which are nearly 2,000 feet high.

(See \_A Sketch of the Geology of the Isle of Man\_, by John Horne, F.G.S.

\_Trans. of the Edin. Geol. Soc.\_ Vol. II. pt. 3, 1874.)

[37] \_The Great Ice Age\_, p. 177.

[38] These are named, in descending order, Hessle Boulder Clay, Purple

Boulder Clay, Chalky Boulder Clay, and Lower Boulder Clay--below which is

the Norwich Crag.

[39] "On the Climate of the Post-Glacial Period." \_Geological Magazine\_,

1872, pp. 158, 160.

[40] \_Geological Magazine\_, 1876, p. 396.

[41] \_Early Man in Britain and his Place in the Tertiary Period\_, p. 113.

[42] Heer's \_PrimÃ¦val World of Switzerland\_ Vol. II., pp. 148-168.

[43] Dr. James Geikie in \_Geological Magazine\_, 1878, p. 77.

[44] This subject is admirably discussed in Professor Asa Gray's Lecture on

"Forest Geography and ArchÃ¦ology" in the \_American Journal of Science and

Arts\_, Vol. XVI. 1878.

[45] In a letter to \_Nature\_ of October 30th, 1879, the Rev. O. Fisher

calls attention to a result arrived at by Pouillet, that the temperature

which the surface of the ground would assume if the sun were extinguished

would be -128Â° F. instead of -239Â° F. If this corrected amount were used in

our calculations, the January temperature of England during the glacial

epoch would come out 17Â° F., and this Mr. Fisher thinks not low enough to

cause any extreme difference from the present climate. In this opinion,

however, I cannot agree with him. On the contrary, it would, I think, be a

relief to the theory were the amounts of decrease of temperature in winter

and increase in summer rendered more moderate, since according to the usual

calculation (which I have adopted) the differences are unnecessarily great.

I cannot therefore think that this modification of the temperatures, should

it be ultimately proved to be correct (which is altogether denied by Dr.

Croll), would be any serious objection to the adoption of Dr. Croll's

theory of the Astronomical and Physical causes of the Glacial Epoch.

The reason of the theoretical increase of summer heat being greater than

the decrease of winter cold is because we are now nearest the sun in winter

and farthest in summer, whereas we calculate the temperatures of the

glacial epoch for the phase of precession when the \_aphelion\_ was in

winter. A large part of the increase of temperature would no doubt be used

up in melting ice and evaporating water, so that there would be a much less

increase of sensible heat; while only a portion of the theoretical lowering

of temperature in winter would be actually produced owing to equalising

effect of winds and currents, and the storing up of heat by the earth and

ocean.

[46] Dr. Croll says this "is one of the most widespread and fundamental

errors within the whole range of geological climatology." The temperature

of the snow itself is, he says, one of the main factors. (\_Climate and

Cosmology\_, p. 85.) But surely the temperature of the snow must depend on

the temperature of the air through which it falls.

[47] In an account of Prof. NordenskjÃ¶ld's recent expedition round the

northern coast of Asia, given in \_Nature\_, November 20th, 1879, we have the

following passage, fully supporting the statement in the text. "Along the

whole coast, from the White Sea to Behring's Straits, no glacier was seen.

During autumn the Siberian coast is nearly free of ice and snow. There are

no mountains covered all the year round with snow, although some of them

rise to a height of more than 2,000 feet." It must be remembered that the

north coast of Eastern Siberia is in the area of supposed greatest winter

cold on the globe.

[48] Dr. Croll objects to this argument on the ground that Greenland and

the Antarctic continent are probably lowlands or groups of islands.

(\_Climate and Cosmology\_, Chap. V.)

[49] "On the Glacial Epoch," by James Croll. \_Geol. Mag.\_ July, August,

1874.

[50] "The general absence of recent marks of glacial action in Eastern

Europe is well known; and the series of changes which have been so well

traced and described by Prof. SzabÃ³ as occurring in those districts seems

to leave no room for those periodical extensions of 'ice-caps' with which

some authors in this country have amused themselves and their readers. Mr.

Campbell, whose ability to recognise the physical evidence of glaciers will

scarcely be questioned, finds quite the same absence of the proof of

extensive ice-action in North America, westward of the meridian of

Chicago." (Prof. J. W. Judd in \_Geol. Mag.\_ 1876, p. 535.)

The same author notes the diminution of marks of ice-action on going

eastward in the Alps; and the Altai Mountains far in Central Asia show no

signs of having been largely glaciated. West of the Rocky Mountains,

however, in the Sierra Nevada and the coast ranges further north, signs of

extensive old glaciers again appear; all which phenomena are strikingly in

accordance with the theory here advocated, of the absolute dependence of

glaciation on abundant rainfall and elevated snow-condensers and

accumulators.

[51] I have somewhat modified this whole passage in the endeavour to

represent more accurately the difference between the views of Dr. Croll and

Sir Charles Lyell.

[52] For numerous details and illustrations see the paper--"On Ocean

Currents in Relation to the Physical Theory of Secular Changes of

Climate"--in the \_Philosophical Magazine\_, 1870.

[53] See \_Darwin's Naturalist's Voyage Round the World\_, 2nd Edition, pp.

244-251.

[54] The influence of geographical changes on climate is now held by many

geologists who oppose what they consider the extravagant hypotheses of Dr.

Croll. Thus, Prof. Dana imputes the glacial epoch chiefly, if not wholly,

to elevation of the land caused by the lateral pressure due to shrinking of

the earth's crust that has caused all other elevations and depressions. He

says: "Now, that elevation of the land over the higher latitudes which

brought on the glacial era is a natural result of the same agency, and a

natural, and almost necessary, counterpart of the coral-island subsidence

which must have been then in progress. The accumulating, folding,

solidification, and crystallisation of rocks attending all the rock-making

and mountain-making through the PalÃ¦ozoic, Mesozoic, and Cenozoic eras, had

greatly stiffened the crust in these parts; and hence in after times, the

continental movements resulting from the lateral pressure necessarily

appeared over the more northern portions of the continent, where the

accumulations and other changes had been relatively small. To the

subsidence which followed the elevation the weight of the ice-cap may have

contributed in some small degree. But the great balancing movements of the

crust of the continental and oceanic areas then going forward must have had

a greatly preponderating effect in the oscillating agency of all

time--lateral pressure within the crust." (\_American Journal of Science and

Arts\_, 3rd Series, Vol. IX. p. 318.)

"In the 2nd edition of his \_Manual of Geology\_, Professor Dana suggests

elevation of Arctic lands sufficient to exclude the Gulf Stream, as a

source of cold during glacial epochs. This, he thinks, would have made an

epoch of cold at any era of the globe. A deep submergence of Behring's

Strait, letting in the Pacific warm current to the polar area, would have

produced a mild Arctic climate like that of the Miocene period. When the

warm current was shut out from the polar area it would yet reach near to

it, and bring with it that abundant moisture necessary for glaciation."

(\_Manual of Geology\_, 2nd Edition, pp. 541-755, 756.)

[55] Dana's \_Manual of Geology\_, 2nd Edition, p. 540.

[56] Dr. Croll says that I here assume an impossible state of things. He

maintains "that the change from the distant sun in winter, and near sun in

summer to the near sun in winter and distant sun in summer, aided by the

change in the physical causes which this would necessarily bring about,

would certainly be sufficient to cause the snow and ice to disappear."

(\_Climate and Cosmology\_, p. 106.) But I demur to his "necessarily." It is

not the \_direct\_ effect of the nearer sun in winter that is supposed to

melt the snow and ice, but the "physical causes," such as absence of fogs

and increase of warm equatorial currents. But the near sun in winter acting

on an ice-clad surface would only increase the fogs and snow, while the

currents could only change if a large portion of the ice were first melted,

in which case they would no doubt be modified so as to cause a further

melting of the ice. Dr. Croll says: "The warm and equable conditions of

climate which would then prevail, and the enormous quantity of

intertropical water carried into the Southern Ocean, would soon produce a

melting of the ice." (\_Loc. cit.\_ p. 111.) This seems to me to be assuming

the very point at issue. He has himself shown that the presence of large

quantities of ice prevents "a warm and equable climate" however great may

be the sun-heat; the ice therefore would \_not\_ be melted, and there would

be no increased flow of intertropical water to the Southern Ocean. The

ocean currents are mainly due to the difference of temperature of the polar

and equatorial areas combined with the peculiar form and position of the

continents, and some one or more of these factors must be altered \_before\_

the ocean currents towards the north pole can be increased. The only factor

available is the Antarctic ice, and if this were largely increased, the

northward-flowing currents might be so increased as to melt some of the

Arctic ice. But the very same argument applies to both poles. Without some

geographical change the Antarctic ice could not materially diminish during

its winter in \_perihelion\_, nor increase to any important extent during the

opposite phase. We therefore seem to have no available agency by which to

get rid of the ice over a glaciated hemisphere, \_so long as the

geographical conditions remained unchanged and the excentricity continued

high\_.

[57] In the \_Geological Magazine\_, April, 1880, Mr. Searles V. Wood adduces

what he considers to be the "conclusive objection" to Dr. Croll's

excentricity theory, which is, that during the last glacial epoch Europe

and North America were glaciated very much in proportion to their

respective climates now, which are generally admitted to be due to the

distribution of oceanic currents. But Dr. Croll admits his theory "to be

baseless unless there was a complete diversion of the warm ocean currents

from the hemisphere glaciated," in which case there ought to be no

difference in the extent of glaciation in Europe and North America. Whether

or not this is a correct statement of Dr. Croll's theory, the above

objection certainly does not apply to the views here advocated; but as I

also hold the "excentricity theory" in a modified form, it may be as well

to show why it does not apply. In the first place I do not believe that the

Gulf Stream was "completely diverted" during the glacial epoch, but that it

was diminished in force, and (as described at p. 144) \_partly\_ diverted

southward. A portion of its influence would, however, still remain to cause

a difference between the climates of the two sides of the Atlantic; and to

this must be added two other causes--the far greater penetration of warm

sea-water into the European than into the North American continent, and the

proximity to America of the enormous ice-producing mass of Greenland. We

have thus three distinct causes, all combining to produce a more severe

winter climate on the west than on the east of the Atlantic during the

glacial epoch, and though the first of these--the Gulf Stream--was not

nearly so powerful as it is now, neither is the difference indicated by the

ice-extension in the two countries so great as the present difference of

winter-temperature, which is the essential point to be considered. The

ice-sheet of the United States is usually supposed to have extended about

ten, or, at most, twelve, degrees further south than it did in Western

Europe, whereas we must go twenty degrees further south in the former

country to obtain the same mean winter-temperature we find in the latter,

as may be seen by examining any map of winter isothermals. This difference

very fairly corresponds to the difference of conditions existing during the

glacial epoch and the present time, so far as we are able to estimate them,

and it certainly affords no grounds of objection to the theory by which the

glaciation is here explained.

[58] Dr. Croll objects to this argument, and adduces the case of Greenland

as showing that ice may accumulate far from sea. But the width of Greenland

is small compared with that of the supposed Antarctic ice-cap. (\_Climate

and Cosmology\_, p. 78.)

[59] The recent extensive glaciation of New Zealand is generally imputed by

the local geologists to a greater elevation of the land; but I cannot help

believing that the high phase of excentricity which caused our own glacial

epoch was at all events an assisting cause. This is rendered more probable

if taken in connection with the following very definite statement of

glacial markings in South Africa. Captain Aylward in his \_Transvaal of

To-day\_ (p. 171) says:--"It will be interesting to geologists and others to

learn that the entire country, from the summits of the Quathlamba to the

junction of the Vaal and Orange rivers, shows marks of having been swept

over, and that at no very distant period, by vast masses of ice from east

to west. The striations are plainly visible, scarring the older rocks, and

marking the hill-sides--getting lower and lower and less visible as,

descending from the mountains, the kopjies (small hills) stand wider apart;

but wherever the hills narrow towards each other, again showing how the

vast ice-fields were checked, thrown up, and raised against their Eastern

extremities."

This passage is evidently written by a person familiar with the phenomena

of glaciation, and as Captain Aylward's preface is dated from Edinburgh, he

has probably seen similar markings in Scotland. The country described

consists of the most extensive and lofty plateau in South Africa, rising to

a mountain knot with peaks more than 10,000 feet high, thus offering an

appropriate area for the condensation of vapour and the accumulation of

snow. At present, however, the mountains do not reach the snow-line, and

there is no proof that they have been much higher in recent times, since

the coast of Natal is now said to be rising. It is evident that no slight

elevation would now lead to the accumulation of snow and ice in these

mountains, situated as they are between 27Â° and 30Â° S. Lat.; since the

Andes, which in 32Â° S. Lat. reach 23,300 feet high, and in 28Â° S. Lat.

20,000, with far more extensive plateaus, produce no ice-fields. We cannot,

therefore, believe that a few thousand feet of additional elevation, even

if it occurred so recently as indicated by the presence of striations,

would have produced the remarkable amount of glaciation above described;

while from the analogy of the northern hemisphere, we may well believe that

it was mainly due to the same high excentricity that led to the glaciation

of Western and Central Europe, and Eastern North America.

These observations confirm those of Mr. G. W. Stow, who, in a paper

published in the \_Quarterly Journal of the Geological Society\_ (Vol. XXVII.

p. 539), describes similar phenomena in the same mountains, and also mounds

and ridges of unstratified clay packed with angular boulders; while further

south the Stormberg mountains are said to be similarly glaciated, with

immense accumulations of morainic matter in all the valleys. We have here

most of the surface phenomena characteristic of a glaciated country, only a

few degrees south of the tropic; and taken in connection with the

indications of recent glaciation in New Zealand, and those discovered by

Dr. R. von Lendenfeld in the Australian Alps between 6,000 and 7,000 feet

elevation (\_Nature\_, Vol. XXXII. p. 69), we can hardly doubt the occurrence

of some general and wide-spread cause of glaciation in the southern

hemisphere at a period so recent that the superficial phenomena are almost

as well preserved as in Europe. Other geologists however deny that there

are any distinct indications of glacial action in South Africa; but the

recent discovery by Dr. J. W. Gregory, F.G.S., of the former extension of

glaciers on Mount Kenya 5,000 feet below their present limits, renders

probable the former glaciation of the South African Highlands.

[60] The astronomical facts connected with the motions and appearance of

the planet are taken from a paper by Mr. Edward Carpenter, M.A., in the

\_Geological Magazine\_ of March, 1877, entitled, "Evidence Afforded by Mars

on the Subject of Glacial Periods," but I arrive at somewhat different

conclusions from those of the writer of the paper.

[61] In an article in \_Nature\_ of Jan. 1, 1880, the Rev. T. W. Webb states

that in 1877 the pole of Mars (? the south pole) was, according to

Schiaparelli, entirely free of snow. He remarks also on the regular contour

of the supposed snows of Mars as offering a great contrast to ours, and

also the strongly marked dark border which has often been observed. On the

whole Mr. Webb seems to be of opinion that there can be no really close

resemblance between the physical condition of the Earth and Mars, and that

any arguments founded on such supposed similarity are therefore

untrustworthy.

[62] \_London, Edinburgh and Dublin Philosophical Magazine\_, Vol. XXXVI.,

pp. 144-150 (1868).

[63] \_Climate and Time in their Geological Relations\_, p. 341.

[64] \_Nature\_, Vol. XXI., p. 345, "The Interior of Greenland."

[65] Prof. J. W. Judd says: "In the case of the Alps I know of no glacial

phenomena which are not capable of being explained, like those of New

Zealand, by a great extension of the area of the tracts above the snow-line

which would collect more ample supplies for the glaciers protruded into

surrounding plains. And when we survey the grand panoramas of ridges,

pinnacles, and peaks produced for the most part by sub-aÃ«rial action, we

may well be prepared to admit that before the intervening ravines and

valleys were excavated, the glaciers shed from the elevated plateaux must

have been of vastly greater magnitude than at present." (Contributions to

the Study of Volcanoes, \_Geological Magazine\_, 1876, p. 536.) Professor

Judd applies these remarks to the last as well as to previous glacial

periods in the Alps; but surely there has been no such extensive alteration

and lowering of the surface of the country since the erratic blocks were

deposited on the Jura and the great moraines formed in North Italy, as this

theory would imply. We can hardly suppose wide areas to have been lowered

thousands of feet by denudation, and yet have left other adjacent areas

apparently untouched; and it is even very doubtful whether such an

extension of the snow-fields would alone suffice for the effects which were

certainly produced.

[66] \_Geological Magazine\_, 1876, p. 392.

[67] Colonel Fielden thinks that these trees have all been brought down by

rivers, and have been stranded on shores which have been recently elevated.

See \_Trans. of Norfolk Nat. Hist. Soc., Vol. III.\_, 1880.

[68] \_Geological Magazine\_, 1876, "Geology of Spitzbergen," p. 267.

[69] The preceding account is mostly derived from Professor Heer's great

work \_Flora Fossilis Arctica\_.

[70] \_Geological Magazine\_, 1875, p. 531.

[71] \_Geological Magazine\_, 1876, p. 266. In his recent work--\_Climate and

Cosmology\_ (pp. 164, 172)--the late Dr. Croll has appealed to the

imperfection of the geological record as a reply to these arguments; in

this case, as it appears to me, a very unsuccessful one.

[72] It is interesting to observe that the Cretaceous flora of the United

States (that of the Dakota group), indicates a somewhat cooler climate than

that of the following Eocene period. Mr. De Rance (in the geological

appendix to Capt. Sir G. Nares's \_Narrative of a Voyage to the Polar Sea\_)

remarks as follows: "In the overlying American Eocenes occur types of

plants occurring in the European Miocenes and still living, proving the

truth of Professor Lesquereux's postulate, that the plant types appear in

America a stage in advance of their advent in Europe. These plants point to

a far higher mean temperature than those of the Dakota group, to a dense

atmosphere of vapour, and a luxuriance of ferns and palms." This is very

important as adding further proof to the view that the climates of former

periods are not due to any general refrigeration, but to causes which were

subject to change and alternation in former ages as now.

[73] Mr. S. B. J. Skertchley informs me that he has himself observed thick

Tertiary deposits, consisting of clays and anhydrous gypsum, at Berenice on

the borders of Egypt and Nubia, at a height of about 600 feet above the

sea-level; but these may have been of fresh-water origin.

[74] By referring to our map of the Indian Ocean showing the submarine

banks indicating ancient islands (Chap. XIX.), it will be evident that the

south-east trade-winds--then exceptionally powerful--would cause a vast

body of water to enter the deep Arabian Sea.

[75] In his recently published \_Lectures on Physical Geography\_, Professor

Haughton calculates, that more than half the solar heat of the torrid zone

is carried to the temperate zones by ocean currents. The Gulf Stream itself

carries one-twelfth of the total amount, but it is probable that a very

small fraction of this quantity of heat reaches the polar seas owing to the

wide area over which the current spreads in the North Atlantic. The

corresponding stream of the Indian Ocean in Miocene times would have been

fully equal to the Gulf Stream in heating power, while, owing to its being

so much more concentrated, a large proportion of its heat may have reached

the polar area. But the Arctic Ocean occupies less than one-tenth of the

area of the tropical seas; so that, whatever proportion of the heat of the

tropical zone was conveyed to it, would, by being concentrated into

one-tenth of the surface, produce an enormously increased effect. Taking

this into consideration, we can hardly doubt that the opening of a

sufficient passage from the Indian Ocean to the Arctic seas would produce

the effects above indicated.

[76] For an account of the resemblances and differences of the mammalia of

the two continents during the Tertiary epoch, see my \_Geographical

Distribution of Animals\_, Vol. I. pp. 140-156.

[77] Professor Haughton has made an elaborate calculation of the difference

between existing climates and those of Miocene times, for all the places

where a Miocene flora has been discovered, by means of the actual range of

corresponding species and genera of plants. Although this method is open to

the objection that the ranges of plants and animals are not determined by

temperature only, yet the results may be approximately correct, and are

very interesting. The following table which summarizes these results is

taken from his Lectures on Physical Geography (p. 344):--

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

| | | Present | Miocene | |

| |Latitude.|Temperature.|Temperature.|Difference.|

|\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_|

| 1. Switzerland | 47d.00 | 53d.6 F | 69d.8 F | 16d.2 F |

| 2. Dantzig | 54d.21 | 45d.7 ,, | 62d.6 ,, | 16d.9 ,, |

| 3. Iceland | 65d.30 | 35d.6 ,, | 48d.2 ,, | 12d.6 ,, |

| 4. Mackenzie River | 65d.00 | 19d.4 ,, | 48d.2 ,, | 28d.8 ,, |

| 5. Disco (Greenland)| 70d.00 | 19d.6 ,, | 55d.6 ,, | 36d.0 ,, |

| 6. Spitzbergen | 78d.00 | 16d.5 ,, | 51d.8 ,, | 35d.3 ,, |

| 7. Grinnell Land | 81d.44 | 1d.7 ,, | 42d.3 ,, | 44d.0 ,, |

|\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_|

It is interesting to note that Iceland, which is now exposed to the full

influence of the Gulf Stream, was only 12Â°.6 F. warmer in Miocene times,

while Mackenzie River, now totally removed from its influence was 28Â°

warmer. This, as well as, the greater increase of temperature as we go

northward and the polar area becomes more limited, is quite in accordance

with the view of the causes which brought about the Miocene climate which

is here advocated.

[78] The objection has been made, that the long polar night would of itself

be fatal to the existence of such a luxuriant vegetation as we know to have

existed as far as 80Â° N. Lat., and that there must have been some

alteration of the position of the pole, or diminution of the obliquity of

the ecliptic, to permit such plants as magnolias and large-leaved maples to

flourish. But there appears to be really no valid grounds for such an

objection. Not only are numbers of Alpine and Arctic evergreens deeply

buried in the snow for many months without injury, but a variety of

tropical and sub-tropical plants are preserved in the hot-houses of St.

Petersburg and other northern cities, which are closely matted during

winter, and are thus exposed to as much darkness as the night of the Arctic

regions. We have besides no proof that any of the Arctic trees or large

shrubs were evergreens, and the darkness would certainly not be prejudical

to deciduous plants. With a suitable temperature there is nothing to

prevent a luxuriant vegetation up to the pole, and the long continued day

is known to be highly favourable to the development of foliage, which in

the same species is larger and better developed in Norway than in the south

of England.

[79] \_Geological Magazine\_, 1873, p. 320.

[80] \_Geological Magazine\_, 1877, p. 137.

[81] \_Manual of Geology\_, 2nd Ed. p. 525. See also letter in \_Nature\_, Vol.

XXIII. p. 410.

[82] \_Nature\_, Vol. XVIII. (July, 1878), p. 268.

[83] "On the Comparative Value of certain Geological Ages considered as

items of Geological Time." (\_Proceedings of the Royal Society\_, 1874, p.

334.)

[84] \_Trans. Royal Society of Edinburgh\_, Vol. XXIII. p. 161. \_Quarterly

Journal of Science\_, 1877. (Croll on the "Probable Origin and Age of the

Sun.")

[85] \_Philosophical Magazine\_, April, 1853.

[86] It has usually been the practice to take the amount of denudation in

the Mississippi valley, or one foot in six thousand years, as a measure of

the rate of denudation in Europe, from an idea apparently of being on the

"safe side," and of not over-estimating the rate of change. But this

appears to me a most unphilosophical mode of proceeding and unworthy of

scientific inquiry. What should we think of astronomers if they always took

the lowest estimates of planetary or stellar distances, instead of the mean

results of observation, "in order to be on the safe side!"? As if error in

one direction were any worse than error in another. Yet this is what

geologists do systematically. Whenever any calculations are made involving

the antiquity of man, it is those that give the \_lowest\_ results that are

always taken, for no reason apparently except that there was, for so long a

time, a prejudice, both popular and scientific, against the great antiquity

of man; and now that a means has been found of measuring the rate of

denudation, they take the slowest rate instead of the mean rate, apparently

only because there is now a scientific prejudice in favour of extremely

slow geological change. I take the mean of the whole; and as this is almost

exactly the same as the mean of the three great European rivers--the Rhone,

Danube, and Po--I cannot believe that this will not be nearer the truth for

Europe than taking one North American river as the standard.

[87] "On the Height of the Land and the Depth of the Ocean," in the

\_Scottish Geographical Magazine\_, 1888.

[88] These figures are merely used to give an idea of the rate at which

denudation is actually going on now; but if no elevatory forces were at

work, the rate of denudation would certainly diminish as the mountains were

lowered and the slope of the ground everywhere rendered flatter. This would

follow not only from the diminished power of rain and rivers, but because

the climate would become more uniform, the rainfall probably less, and no

rocky peaks would be left to be fractured and broken up by the action of

frosts. It is certain, however, that no continent has ever remained long

subject to the influences of denudation alone, for, as we have seen in our

sixth chapter, elevation and depression have always been going on in one

part or other of the surface.

[89] The following statement of the depths at which the PalÃ¦ozoic

formations have been reached in various localities in and round London was

given by Mr. H. B. Woodward in his address to the Norwich Geological

Society in 1879:--

\_Deep Wells through the Tertiary and Cretaceous Formations.\_

Harwich at 1,022 feet reached Carboniferous Rock.

Kentish Town ,, 1,114 ,, ,, Old Red Sandstone.

Tottenham Court Road ,, 1,064 ,, ,, Devonian.

Blackwall ,, 1,004 ,, ,, Devonian or Old Red Sandstone.

Ware ,, 800 ,, ,, Silurian (Wenlock Shale).

We thus find that over a wide area, extending from London to Ware and

Harwich, the whole of the formations from the Oolite to the Permian are

wanting, the Cretaceous resting on the Carboniferous or older PalÃ¦ozoic

rocks; and the same deficiency extends across to Belgium, where the

Tertiary beds are found resting on Carboniferous at a depth of less than

400 feet.

[90] \_Geological Magazine\_, Vol. VIII., March, 1871.

[91] Mr. C. Lloyd Morgan has well illustrated this point by comparing the

generally tilted-up strata denuded on their edges, to a library in which a

fire had acted on the exposed edges of the books, destroying a great mass

of literature but leaving a portion of each book in its place, which

portion represents the thickness but not the size of the book. (\_Geological

Magazine\_, 1878, p. 161.)

[92] Professor J. Young thinks it highly probable that--"the Lower

Greensand is contemporaneous with part of the Chalk, so were parts of the

Wealden; nay, even of the Purbeck a portion must have been forming while

the Cretaceous sea was gradually deepening southward and westward." Yet

these deposits are always arranged successively, and their several

thicknesses added together to obtain the total thickness of the formations

of the country. (See Presidential Address, Sect. C. British Association,

1876.)

[93] Mr. John Murray in his more careful estimate makes it about 51Â½

millions.

[94] As by far the larger portion of the denuded matter of the globe passes

to the sea through comparatively few great rivers, the deposits must often

be confined to very limited areas. Thus the denudation of the vast

Mississippi basin must be almost all deposited in a limited portion of the

Gulf of Mexico, that of the Nile within a small area of the Eastern

Mediterranean, and that of the great rivers of China--the Hoang Ho and

Yang-tse-kiang, in a small portion of the Eastern Sea. Enormous lengths of

coast, like those of Western America and Eastern Africa, receive very

scanty deposits; so that thirty miles in width along the whole of the

coasts of the globe will probably give an area greater than that of the

area of \_average\_ deposit, and certainly greater than that of \_maximum\_

deposit, which is the basis on which I have here made my estimates. In the

case of the Mississippi, it is stated by Count Pourtales that along the

plateau between the mouth of the river and the southern extremity of

Florida for two hundred and fifty miles in width the bottom consists of

clay with some sand and but few Rhizopods; but beyond this distance the

soundings brought up either Rhizopod shells alone, or these mixed with

coral sand, Nullipores, and other calcareous organisms (Dana's \_Manual of

Geology\_, 2nd Ed. p. 671). It is probable, therefore, that a large

proportion of the entire mass of sediment brought down by the Mississippi

is deposited on the limited area above indicated.

Professor Dana further remarks: "Over interior oceanic basins as well as

off a coast in quiet depths, fifteen or twenty fathoms and beyond, the

deposits are mostly of fine silt, fitted for making fine argillaceous

rocks, as shales or slates. When, however, the depth of the ocean falls off

below a hundred fathoms, the deposition of silt in our existing oceans

mostly ceases, unless in the case of a great bank along the border of a

continent."

[95] From the same data Professor Haughton estimates a minimum of 200

million years for the duration of geological time; but he arrives at this

conclusion by supposing the products of denudation to be uniformly spread

over the \_whole sea-bottom\_ instead of over a narrow belt near the coasts,

a supposition entirely opposed to all the known facts, and which had been

shown by Dr. Croll, five years previously, to be altogether erroneous. (See

\_Nature\_, Vol. XVIII., p. 268, where Professor Haughton's paper is given as

read before the Royal Society.)

[96] See \_Geological Magazine\_ for 1877, p. 1.

[97] In his reply to Sir W. Thomson, Professor Huxley \_assumed\_ one foot in

a thousand years as a not improbable rate of deposition. The above estimate

indicates a far higher rate; and this follows from the well-ascertained

fact, that the area of deposition is many times smaller than the area of

denudation.

[98] Dr. Croll and Sir Archibald Geikie have shown that marine denudation

is very small in amount as compared with sub-aÃ«rial, since it acts only

locally on the \_edge\_ of the land, whereas the latter acts over every foot

of the \_surface\_. Mr. W. T. Blanford argues that the difference is still

greater in tropical than in temperate latitudes, and arrives at the

conclusion that--"If over British India the effects of marine to those of

fresh-water denudation in removing the rocks of the country be estimated at

1 to 100, I believe that the result of marine action will be greatly

overstated" (\_Geology and Zoology of Abyssinia\_, p. 158, note). Now, as our

estimate of the rate of sub-aÃ«rial denudation cannot pretend to any precise

accuracy, we are justified in neglecting marine denudation altogether,

especially as we have no method of estimating it for the whole earth with

any approach to correctness.

[99] Agassiz appears to have been the first to suggest that the principal

epochs of life extermination were epochs of cold; and Dana thinks that two

at least such epochs may be recognised, at the close of the PalÃ¦ozoic and

of the Cretaceous periods--to which we may add the last glacial epoch.

[100] This view was, I believe, first put forth by myself in a paper read

before the Geological Section of the British Association in 1869, and

subsequently in an article in \_Nature\_, Vol. I. p. 454. It was also stated

by Mr. S. B. J. Skertchley in his \_Physical System of the Universe\_, p. 363

(1878); but we both founded it on what I now consider the erroneous

doctrine that actual glacial epochs recurred each 10,500 years during

periods of high excentricity.

[101] Explication d'une seconde Ã©dition de la \_Carte GÃ©ologique de la

Terre\_ (1875), p. 64.

[102] For most of the facts as to the zoology and botany of these islands,

I am indebted to Mr. Godman's valuable work--\_Natural History of the Azores

or Western Islands\_, by Frederick Du Cane Godman, F.L.S., F.Z.S., &c.,

London, 1870.

[103] See Chap. V. p. 78.

[104] Some of Mr. Darwin's experiments are very interesting and suggestive.

Ripe hazel-nuts sank immediately, but when dried they floated for ninety

days, and afterwards germinated. An asparagus-plant with ripe berries, when

dried, floated for eighty-five days, and the seeds afterwards germinated.

Out of ninety-four dried plants experimented with, eighteen floated for

more than a month, and some for three months, and their powers of

germination seem never to have been wholly destroyed. Now, as oceanic

currents vary from thirty to sixty miles a day, such plants under the most

favourable conditions might be carried 90 X 60 = 5,400 miles! But even half

of this is ample to enable them to reach any oceanic island, and we must

remember that till completely water-logged they might be driven along at a

much greater rate by the wind. Mr. Darwin calculates the distance by the

average time of flotation to be 924 miles; but in such a case as this we

are entitled to take the extreme cases, because such countless thousands of

plants and seeds must be carried out to sea annually that the extreme cases

in a single experiment with only ninety-four plants, must happen hundreds

or thousands of times and with hundreds or thousands of species, naturally,

and thus afford ample opportunities for successful migration. (See \_Origin

of Species\_, 6th Edition, p. 325.)

[105] The following remarks, kindly communicated to me by Mr. H. N.

Moseley, naturalist to the \_Challenger\_, throw much light on the agency of

birds in the distribution of plants:--"Grisebach (\_Veg. der Erde\_, Vol. II.

p. 496) lays much stress on the wide ranging of the albatross (Diomedea)

across the equator from Cape Horn to the Kurile Islands, and thinks that

the presence of the same plants in Arctic and Antarctic regions may be

accounted for, possibly, by this fact. I was much struck at Marion Island

of the Prince Edward group, by observing that the great albatross breeds in

the midst of a dense, low herbage, and constructs its nest of a mound of

turf and herbage. Some of the indigenous plants, \_e.g.\_ AcÃ¦na, have

flower-heads which stick like burrs to feathers, &c., and seem specially

adapted for transposition by birds. Besides the albatrosses, various

species of Procellaria and Puffinus, birds which range over immense

distances may, I think, have played a great part in the distribution of

plants, and especially account, in some measure, for the otherwise

difficult fact (when occurring in the tropics), that widely distant islands

have similar mountain plants. The Procellaria and Puffinus in nesting,

burrow in the ground, as far as I have seen choosing often places where the

vegetation is the thickest. The birds in burrowing get their feathers

covered with vegetable mould, which must include spores, and often seeds.

In high latitudes the birds often burrow near the sea-level, as at Tristan

d'Acunha or Kerguelen's Land, but in the tropics they choose the mountains

for their nesting-place (Finsch and Hartlaub, \_Orn. der Viti- und

Tonga-Inseln\_, 1867, Einleitung, p. xviii.). Thus, \_Puffinus megasi\_ nests

at the top of the Korobasa basaga mountain, Viti Levu, fifty miles from the

sea. A Procellaria breeds in like manner in the high mountains of Jamaica,

I believe at 7,000 feet. Peale describes the same habit of \_Procellaria

rostrata\_ at Tahiti, and I saw the burrows myself amidst a dense growth of

fern, &c., at 4,400 feet elevation in that island. Phaethon has a similar

habit. It nests at the crater of Kilauea, Hawaii, at 4,000 feet elevation,

and also high up in Tahiti. In order to account for the transportation of

the plants, it is not of course necessary that the same species of

Procellaria or Diomedea should now range between the distant points where

the plants occur. The ancestor of the now differing species might have

carried the seeds. The range of the genus is sufficient."

[106] \_Nature\_, Vol. VI. p. 262, "Recent Observations in the Bermudas," by

Mr. J. Matthew Jones.

[107] "The late Sir C. Wyville Thomson was of opinion that the 'red earth'

which largely forms the soil of Bermuda had an organic origin, as well as

the 'red clay' which the \_Challenger\_ discovered in all the greater depths

of the ocean basins. He regarded the red earth and red clay as an ash left

behind after the gradual removal of the lime by water charged with carbonic

acid. This ash he regarded as a constituent part of the shells of

Foraminifera, skeletons of Corals, and Molluscs, [\_vide\_ \_Voyage of the

Challenger\_, Atlantic, Vol. I. p. 316]. This theory does not seem to be in

any way tenable. Analysis of carefully selected shells of Foraminifera,

Heteropods, and Pteropods, did not show the slightest trace of alumina, and

none has as yet been discovered in coral skeletons. It is most probable

that a large part of the clayey matter found in red clay and the red earth

of Bermuda is derived from the disintegration of pumice, which is

continually found floating on the surface of the sea. [See Murray, "On the

Distribution of Volcanic DÃ©bris Over the Floor of the Ocean;" \_Proc. Roy.

Soc. Edin.\_ Vol. IX. pp. 247-261. 1876-1877.] The naturalists of the

\_Challenger\_ found it among the floating masses of gulf weed, and it is

frequently picked up on the reefs of Bermuda and other coral islands. The

red earth contains a good many fragments of magnetite, augite, felspar, and

glassy fragments, and when a large quantity of the rock of Bermuda is

dissolved away with acid, a small number of fragments are also met with.

These mineral particles most probably came originally from the pumice which

had been cast up on the island for long ages (for it is known that these

minerals are present in pumice), although possibly some of them may have

come from the volcanic rock, which is believed to form the nucleus of the

island." \_The Voyage of H.M.S. Challenger\_, Narrative of the Cruise, Vol.

I. 1885, pp. 141-142.

[108] Four bats occur rarely, two being N. American, and two West Indian

Species. \_The Bermuda Islands\_, by Angelo Heilprin, Philadelphia, 1889.

[109] Fourteen species of Spiders were collected by Prof. A. Heilprin, all

American or cosmopolitan species except one, \_Lycosa atlantica\_, which Dr.

Marx of Washington describes as new and as peculiar to the islands.

(Heilprin's \_The Bermudas\_, p. 93.)

[110] Mr. Theo. D. A. Cockerell informs me that there are two slugs in

Bermuda of which specimens exist in the British Museum,--\_Amalia gagates\_

Drap. common in Europe, and \_Agriolimax campestris\_ of the United States.

Both may therefore have been introduced by human agency. Also \_Vaginulus

Morelete var. schivelyÃ¦\_ which seems to be a variety of a Mexican species;

perhaps imported.

[111] "Notes on the Vegetation of Bermuda," by H. N. Moseley. (\_Journal of

the Linnean Society\_, Vol. XIV., \_Botany\_, p. 317.)

[112] \_Gigantic Land Tortoises Living and Extinct in the Collection of the

British Museum.\_ By A. C. L. G. GÃ¼nther, F.R.S. 1877.

[113] The following list of the beetles yet known from the Galapagos shows

their scanty proportions and accidental character; the forty species

belonging to thirty-three genera and eighteen families. It is taken from

Mr. Waterhouse's enumeration in the \_Proceedings of the Zoological Society\_

for 1877 (p. 81), with a few additions collected by the U. S. Fish

Commission Steamer \_Albatross\_, and published by the U. S. National Museum

in 1889.

CARABIDÃ. ELATERIDÃ.

Feronia calathoides. Physorhinus galapagoensis

,, insularis. HETEROMERA.

,, galapagoensis. Allecula n. s.

Amblygnathus obscuricornis. Stomion helopoides.

Solenophorus galapagoensis. ,, lÃ¦vigatum.

Notaphus galapagoensis. Ammophorus obscurus.

DYTISCIDÃ. ,, cooksoni.

Eunectes occidentalis. ,, bifoveatus.

Acilius incisus. Pedonoeces galapagoensis.

Copelatus galapagoensis. ,, pubescens.

PALPICORNES. Phaleria manicata.

Tropisternus lateralis. CURCULIONIDÃ.

Philhydrus sp. Otiorhynchus cuneiformis.

STAPHYLINIDÃ. Anchonus galapagoensis.

Creophilus villosus. LONGICORNIA.

NECROPHAGA. Mallodou sp.

Acribis serrativentris. Eburia amabilis.

Phalacrus darwinii. ANTHRIBIDÃ.

Dermestes vulpinus. Ormiscus variegatus.

MALACODERMS. PHYTOPHAGA

Ablechrus darwinii. Diabrotica limbata.

Corynetes rufipes. Docema galapagoensis.

Bostrichus unciniatus. Longitarsus lunatus.

Tetrapriocerca sp. SECURIPALPES.

LAMELLICORNES. Scymuns galapagoensis.

Copris lugubris.

Oryctes galapagoensis.

[114] Mr. H. O. Forbes, who visited these islands in 1878, increased the

number of wild plants to thirty-six, and these belonged to twenty-six

natural orders.

[115] Juan Fernandez is a good example of a small island which, with time

and favourable conditions, has acquired a tolerably rich and highly

peculiar flora and fauna. It is situated in 34Â° S. Lat., 400 miles from the

coast of Chile, and so far as facilities for the transport of living

organisms are concerned is by no means in a favourable position, for the

ocean-currents come from the south-west in a direction where there is no

land but the Antarctic continent, and the prevalent winds are also

westerly. No doubt, however, there are occasional storms, and there may

have been intermediate islands, but its chief advantages are its antiquity,

its varied surface, and its favourable soil and climate, offering many

chances for the preservation and increase of whatever plants and animals

have chanced to reach it. The island consists of basalt, greenstone, and

other ancient rocks, and though only about twelve miles long its mountains

are three thousand feet high. Enjoying a moist and temperate climate it is

especially adapted to the growth of ferns, which are very abundant; and as

the spores of these plants are as fine as dust, and very easily carried for

enormous distances by winds, it is not surprising that there are nearly

fifty species on the island, while the remote period when it first received

its vegetation may be indicated by the fact that nearly half the species

are quite peculiar; while of 102 species of flowering plants seventy are

peculiar, and there are ten peculiar genera. The same general character

pervades the fauna. For so small an island it is rich, containing four true

land-birds, about fifty species of insects, and twenty of land-shells.

Almost all these belong to South American genera, and a large proportion

are South American species; but several of the insects, half the birds, and

the whole of the land-shells are peculiar. This seems to indicate that the

means of transmission were formerly greater than they are now, and that in

the case of land-shells none have been introduced for so long a period that

all have become modified into distinct forms, or have been preserved on the

island while they have become extinct on the continent. For a detailed

examination of the causes which have led to the modification of the humming

birds of Juan Fernandez see the chapter on Humming Birds in the author's

\_Natural Selection and Tropical Nature\_, p. 324; while a general account of

the fauna of the island is given in his \_Geographical Distribution of

Animals\_, Vol. II. p. 49.

[116] No additions appear to have been made to this flora down to 1885,

when Mr. Hemsley published his \_Report on the Present State of our

Knowledge of Insular Floras\_.

[117] \_Journal of the Linnean Society\_, Vol. XIII., "Botany," p. 556.

[118] \_Geographical Distribution of Animals\_, Vol. II. p. 81.

[119] \_St. Helena: a Physical, Historical, and Topographical Description of

the Island, &c.\_ By John Charles Melliss, F.G.S., &c. London: 1875.

[120] Mr. Marsh in his interesting work entitled \_The Earth as Modified by

Human Action\_ (p. 51), thus remarks on the effect of browsing quadrupeds in

destroying and checking woody vegetation.--"I am convinced that forests

would soon cover many parts of the Arabian and African deserts if man and

domestic animals, especially the goat and the camel, were banished from

them. The hard palate and tongue, and strong teeth and jaws of this latter

quadruped enable him to break off and masticate tough and thorny branches

as large as the finger. He is particularly fond of the smaller twigs,

leaves, and seed-pods of the \_Sont\_ and other acacias, which, like the

American robinia, thrive well on dry and sandy soils, and he spares no tree

the branches of which are within his reach, except, if I remember right,

the tamarisk that produces manna. Young trees sprout plentifully around the

springs and along the winter water-courses of the desert, and these are

just the halting stations of the caravans and their routes of travel. In

the shade of these trees annual grasses and perennial shrubs shoot up, but

are mown down by the hungry cattle of the Bedouin as fast as they grow. A

few years of undisturbed vegetation would suffice to cover such points with

groves, and these would gradually extend themselves over soils where now

scarcely any green thing but the bitter colocynth and the poisonous

foxglove is ever seen."

[121] \_Coleoptera SanctÃ¦ HelenÃ¦\_, 1877; \_Testacea Atlantica\_, 1878.

[122] On Petermann's map of Africa, in \_Stieler's Hand-Atlas\_ (1879), the

Island of Ascension is shown as seated on a much larger and shallower

submarine bank than St. Helena. The 1,000 fathom line round Ascension

encloses an oval space 170 miles long by 70 wide, and even the 300 fathom

line, one over 60 miles long; and it is therefore probable that a much

larger island once occupied this site. Now Ascension is nearly equidistant

between St. Helena and Liberia, and such an island might have served as an

intermediate station through which many of the immigrants to St. Helena

passed. As the distances are hardly greater than in the case of the Azores,

this removes whatever difficulty may have been felt of the possibility of

\_any\_ organisms reaching so remote an island. The present island of

Ascension is probably only the summit of a huge volcanic mass, and any

remnant of the original fauna and flora it might have preserved may have

been destroyed by great volcanic eruptions. Mr. Darwin collected some

masses of tufa which were found to be mainly organic, containing, besides

remains of fresh-water infusoria, the siliceous tissue of plants! In the

light of the great extent of the submarine bank on which the island stands,

Mr. Darwin's remark, that--"we may feel sure, that at some former epoch,

the climate and productions of Ascension were very different from what they

are now,"--has received a striking confirmation. (See \_Naturalist's Voyage

Round the World\_, p. 495.)

[123] "Notes on the Classification, History, and Geographical Distribution

of CompositÃ¦."--\_Journal of the Linnean Society\_, Vol. XIII. p. 563 (1873).

[124] The MelhaniÃ¦ comprise the two finest timber trees of St. Helena, now

almost extinct, the redwood and native ebony.

[125] \_Journal of the Linnean Society\_, 1873, p. 496. "On Diversity of

Evolution under one set of External Conditions." \_Proceedings of the

Zoological Society of London\_, 1873, p. 80. "On the Classification of the

AchitinellidÃ¦."

[126] "Memoirs on the Coleoptera of the Hawaiian Islands." By the Rev. T.

Blackburn, B.A., and Dr. D. Sharp. \_Scientific Transactions of the Royal

Dublin Society.\_ Vol. III. Series II. 1885.

[127] See Hildebrand's \_Flora of the Hawaiian Islands\_, Introduction, p.

xiv.

[128] \_Flora of the Hawaiian Islands\_, by W. Hildebrand, M.D., annotated

and published after the author's death by W. F. Hildebrand, 1888.

[129] These are obtained from Hildebrand's \_Flora\_ supplemented by Mr.

Bentham's paper in the \_Journal of the Linnean Society\_.

[130] Among the curious features of the Hawaiian flora is the extraordinary

development of what are usually herbaceous plants into shrubs or trees.

Three species of Viola are shrubs from three to five feet high. A shrubby

Silene is nearly as tall; and an allied endemic genus, Schiedea, has

numerous shrubby species. \_Geranium arboreum\_ is sometimes twelve feet

high. The endemic CompositÃ¦ are mostly shrubs, while several are trees

reaching twenty or thirty feet in height. The numerous LobeliaceÃ¦, all

endemic, are mostly shrubs or trees, often resembling palms or yuccas in

habit, and sometimes twenty-five or thirty feet high. The only native genus

of PrimulaceÃ¦--Lysimachia--consists mainly of shrubs; and even a plantain

has a woody stem sometimes six feet high.

[131] \_Geological Magazine\_, 1870, p. 155.

[132] \_Transactions of the Edinburgh Geological Society\_, Vol. I. p. 330.

[133] \_Quarterly Journal of Geological Society\_, 1850, p. 96.

[134] \_British Association Report\_, Dundee, 1867, p. 431.

[135] The list of names was furnished to me by Dr. GÃ¼nther, and I have

added the localities from the papers containing the original descriptions,

and from Dr. Haughton's \_British Freshwater Fishes\_.

[136] See "The Virginia Colony of Helix nemoralis," T. D. A. Cockerell, in

\_The Nautilus\_, Vol. III. No. 7, p. 73.

[137] I am indebted to Mr. Mitten for this curious fact.

[138] The following remarks by Dr. Richard Spruce, who has made a special

study of mosses and especially of hepaticÃ¦, are of interest. "From what

precedes, I conclude that no existing agency is capable of transporting the

germs of our hepatics of tropical type from the torrid zone to Britain, and

I venture to suppose that their existence at Killarney dates from the

remote period when the vegetation of the whole northern hemisphere partook

of a tropical character. If I am challenged to account for their survival

through the last glacial period, I reply that, granting even the existence

of a universal ice-cap down to the latitude of 40Â° in America and 50Â° in

Europe, it is not to be assumed that the whole extent, even of land, was

\_perennially\_ entombed 'in thrilling regions of thick-ribbed ice.' Towards

the southern margin of the ice the climate was probably very similar to

that of Greenland and the northern part of Norway at the present day. The

summer sun would have great power, and on the borders of sheltered fjords

the frozen snow would disappear completely, if only for a very short

period, and I ask only for a month or two, not doubting the capacity of our

hepatics to survive in a dormant state under the snow for at least ten

months in the year. I have gathered mosses in the Pyrenees where the snow

had barely left them on August 2nd; by September 25th they were re-covered

with snow, and would not be again uncovered till the following year. The

mosses of Killarney might even enjoy a longer summer than this; for the

gulf-stream laves both sides of the south-western angle of Ireland, and its

tepid waters would exert great melting power on the ice-bound coast,

preventing at the same time any formation of ice in the sea itself." This

passage is the conclusion of a very interesting discussion on the

distribution of hepaticÃ¦ in a paper on "A New Hepatic from Killarney," in

the \_Journal of Botany\_, vol. 25, (Feb. 1887), pp. 33-82, in which many

curious facts are given as to the habits and distribution of these curious

and beautiful little plants.

[139] While these pages are passing through the press I am informed by my

friend Mr. W. H. Beeby that in the Shetland Isles, where he has been

collecting for five summers, he has found several plants new to the British

flora, and a few altogether undescribed. Among these latter is a very

distinct species of Hieracium (\_H. Zetlandicum\_), which is quite unknown in

Scandinavia, and is almost certainly peculiar to the British Islands. Here

we have another proof that entirely new species are still to be discovered

in the remoter portions of our country.

[140] In the first edition of this work the numbers were 400 and 340,

showing the great increase of our knowledge during the last ten years,

chiefly owing to the researches of Mr. A. H. Everett in Sarawak and Mr.

John Whitehead in North Borneo and the great mountain Kini Balu.

[141] These are Allocotops, Chlorocharis, Androphilus, and Ptilopyga, among

the TimeliidÃ¦; Tricophoropsis and Oreoctistes among the BrachypodidÃ¦;

Chlamydochoera among the CampophagidÃ¦.

[142] In a letter from Darwin he says:--"Hooker writes to me, 'Miguel has

been telling me that the flora of Sumatra and Borneo are identical, and

that of Java quite different.'"

[143] "On the Geology of Sumatra," by M. R. D. M. Verbeck. \_Geological

Magazine\_, 1877.

[144] \_Pitta megarhynchus\_ (Banca) allied to \_P. brachyurus\_ (Borneo,

Sumatra, Malacca); and \_Pitta bangkanus\_ (Banca) allied to \_P. sordidus\_

(Borneo and Sumatra).

[145] The following list of the mammalia of the Philippines and the Sulu

Islands has been kindly furnished me by Mr. Everett.

QUADRUMANA.

1. Macacus cynomolgus.

2. Tarsius spectrum.

CARNIVORA.

3. Viverra tangalunga.

4. Paradoxurus philippinensis. Also in Palawan.

5. Felis bengalensis. In Negros Island.

UNGULATA.

6. Bubalus mindorensis. Peculiar species.

7. Cervus philippinus. Peculiar species.

8. " alfredi. Peculiar species.

9. " nigricans. Peculiar species.

10. " pseudaxis. Sulu only. Probably introduced.

11. Sus marchesi. Peculiar species.

RODENTIA.

12. Sciurus philippinensis. Peculiar species.

13. Sciurus cagos. Peculiar species.

14. " concinnus. Peculiar. Mindanao and Basilan.

15. PhlÃ¦omys cummingi. Peculiar genus.

16. Mus ephippium.

17. " everetti. Peculiar species.

INSECTIVORA.

18. Crocidura luzoniensis. Peculiar species.

19. Crocidura edwardsiana. Peculiar species.

20. Dendrogale sp.

21. Galeopithecus philippinensis. Peculiar species.

CHIROPTERA.

22. Pteropus leucopterus.

23. " edulis.

24. " hypomelanus.

25. " jubatus.

26. Xantharpyia amplexicaule.

27. Cynopterus marginatus.

28. " jagorii. Peculiar species.

29. Carponycteris australis.

30. Rhinolophus luctus.

31. " philippinensis. Peculiar species.

32. Rhinolophus rufus. Peculiar species.

33. Hipposideros diadema.

34. " pygmÃ¦us. Peculiar species.

35. Hipposideros larvatus.

36. " obscurus. Peculiar species.

37. Hipposideros coronatus. Peculiar species.

38. Hipposideros bicolor.

39. Megaderma spasma.

40. Vesperugo pachypus.

41. " tenuis.

42. Vesperugo abramus.

43. Nycticejus kuhlii.

44. Vespertilio macrotarsus. Peculiar species.

45. Vespertilio capaccinii.

46. Harpiocephalus cyclotis.

47. Kerivoula hardwickii.

48. Kerivoula pellucida. Peculiar species.

49. " jagorii. Peculiar species.

50. Miniopterus schreibersii.

51. " tristis. Peculiar species.

52. Emballonura monticola.

53. Taphyzous melanopogon.

54. Nyctinomus plicatus.

[146] Extracted from Messrs. Blakiston and Pryer's \_Catalogue of Birds of

Japan\_ (\_Ibis\_, 1878, p. 209), with Mr. Seebohm's additions and corrections

in his \_Birds of the Japanese Empire\_ 1890. Accidental stragglers are not

reckoned as British birds.

[147] Mr. Swinhoe died in October, 1877, at the early age of forty-two. His

writings on natural history are chiefly scattered through the volumes of

the \_Proceedings of the Zoological Society\_ and \_The Ibis\_; the whole being

summarised in his \_Catalogue of the Mammals of South China and Formosa\_

(\_P. Z. S.\_, 1870, p. 615), and his \_Catalogue of the Birds of China and

its Islands\_ (\_P. Z. S.\_, 1871, p. 337).

[148] Captain Blakiston has shown that the northern island--Yezo--is much

more temperate and less peculiar in its zoology than the central and

southern islands. This is no doubt dependent chiefly on the considerable

change of climate that occurs on passing the Tsu-garu strait.

[149] See Dr. J. E. Gray's "Revision of the ViverridÃ¦," in \_Proc. Zool.

Soc.\_ 1864, p. 507.

[150] Some of the Bats of Madagascar and East Africa are said to have their

nearest allies in Australia. (See Dobson in \_Nature\_, Vol. XXX. p. 575.)

[151] This view was, I believe, first advanced by Professor Huxley in his

"Anniversary Address to the Geological Society," in 1870. He says:--"In

fact the Miocene mammalian fauna of Europe and the Himalayan regions

contain, associated together, the types which are at present separately

located in the South African and Indian provinces of ArctogÃ¦a. Now there is

every reason to believe, on other grounds, that both Hindostan south of the

Ganges, and Africa south of the Sahara, were separated by a wide sea from

Europe and North Asia during the Middle and Upper Eocene epochs. Hence it

becomes highly probable that the well-known similarities, and no less

remarkable differences, between the present faunÃ¦ of India and South Africa

have arisen in some such fashion as the following: Some time during the

Miocene epoch, the bottom of the nummulitic sea was upheaved and converted

into dry land in the direction of a line extending from Abyssinia to the

mouth of the Ganges. By this means the Dekkan on the one hand and South

Africa on the other, became connected with the Miocene dry land and with

one another. The Miocene mammals spread gradually over this intermediate

dry land; and if the condition of its eastern and western ends offered as

wide contrasts as the valleys of the Ganges and Arabia do now, many forms

which made their way into Africa must have been different from those which

reached the Dekkan, while others might pass into both these sub-provinces."

This question is fully discussed in my \_Geographical Distribution of

Animals\_ (Vol. I., p. 285), where I expressed views somewhat different from

those of Professor Huxley, and made some slight errors which are corrected

in the present work. As I did not then refer to Professor Huxley's prior

statement of the theory of Miocene immigration into Africa (which I had

read but the reference to which I could not recall) I am happy to give his

views here.

[152] The total number of Madagascar birds is 238, of which 129 are

absolutely peculiar to the island, as are thirty-five of the genera. All

the peculiar birds but two are land birds. These are the numbers given in

M. Grandidier's great work on Madagascar.

[153] \_The Ibis\_, 1877, p. 334.

[154] In a paper read before the Geological Society in 1874, Mr. H. F.

Blanford, from the similarity of the fossil plants and reptiles, supposed

that India and South Africa had been connected by a continent, "and

remained so connected with some short intervals from the Permian up to the

end of the Miocene period," and Mr. Woodward expressed his satisfaction

with "this further evidence derived from the fossil flora of the Mesozoic

series of India in corroboration of the former existence of an old

submerged continent--Lemuria."

Those who have read the preceding chapters of the present work will not

need to have pointed out to them how utterly inconclusive is the

fragmentary evidence derived from such remote periods (even if there were

no evidence on the other side) as indicating geographical changes. The

notion that a similarity in the productions of widely separated continents

at any past epoch is only to be explained by the existence of a \_direct\_

land-connection, is entirely opposed to all that we know of the wide and

varying distribution of \_all\_ types at different periods, as well as to the

great powers of dispersal over moderate widths of ocean possessed by all

animals except mammalia. It is no less opposed to what is now known of the

general permanency of the great continental and oceanic areas; while in

this particular case it is totally inconsistent (as has been shown above)

with the actual facts of the distribution of animals.

[155] \_Geographical Distribution of Animals\_, Vol. I., pp. 272-292.

[156] The term "Mascarene" is used here in an extended sense, to include

all the islands near Madagascar which resemble it in their animal and

vegetable productions.

[157] For the birds of the Comoro Islands see \_Proc. Zool. Soc.\_, 1877, p.

295, and 1879, p. 673.

[158] The following is a list of these peculiar birds. (See the \_Ibis\_, for

1867, p. 359; and 1879, p. 97.)

PASSERES.

\_Ellisia seychelensis.\_

\_Copsychus seychellarum.\_

\_Hypsipetes crassirostris.\_

\_Tchitrea corvina.\_

\_Nectarinia dussumieri.\_

\_Zosterops modesta.\_

" \_semiflava.\_

\_Foudia seychellarum.\_

PSITTACI.

\_Coracopsis barklyi.\_

\_PalÃ¦ornis wardi.\_

COLUMBÃ.

\_AlectorÃ¦nas pulcherrimus.\_

\_Turtur rostratus.\_

ACCIPITRES.

\_Tinnunculus gracilis.\_

[159] Specimens are recorded from West Africa in the \_Proceedings of the

Academy of Natural Science\_, Philadelphia, 1857, p. 72, while specimens in

the Paris Museum were brought by D'Orbigny from S. America. Dr. Wright's

specimens from the Seychelles have, as he informs me, been determined to be

the same species by Dr. Peters of Berlin.

[160] "Additional Notes on the Land-shells of the Seychelles Islands." By

Geoffrey Nevill, C.M.Z.S. \_Proc. Zool. Soc.\_ 1869, p. 61.

[161] In Maillard's \_Notes sur l'Isle de RÃ©union\_, a considerable number of

mammalia are given as "wild," such as \_Lemur mongoz\_ and \_Centetes

setosus\_, both Madagascar species, with such undoubtedly introduced animals

as a wild cat, a hare, and several rats and mice. He also gives two species

of frogs, seven lizards, and two snakes. The latter are both Indian species

and certainly imported, as are most probably the frogs. Legouat, who

resided some years in the island nearly two centuries ago, and who was a

closer observer of nature, mentions numerous birds, large bats,

land-tortoises, and lizards, but no other reptiles or venomous animals

except scorpions. We may be pretty sure, therefore, that the land-mammalia,

snakes, and frogs, now found wild, have all been introduced. Of lizards, on

the other hand, there are several species, some peculiar to the island,

others common to Africa and the other Mascarene Islands. The following list

by Prof. Dumeril is given in Maillard's work:--

\_Platydactylus cepedianus.\_

" \_ocellatus.\_

\_Hemidactylus peronii.\_

" \_mutilatus.\_

\_Hemidactylus frenatus.\_

\_Gongylus bojerii.\_

\_Ablepharus peronii.\_

Four species of chameleon are now recorded from Bourbon and one from

Mauritius (J. Reay Greene, M.D., in \_Pop. Science Rev.\_ April, 1880), but

as they are not mentioned by the old writers, it is pretty certain that

these creatures are recent introductions, and this is the more probable as

they are favourite domestic pets.

Darwin informed me that in a work entitled \_Voyage Ã  l'Isle de France, par

un Officier du Roi\_, published in 1770, it is stated that a fresh-water

fish had been introduced from Batavia and had multiplied. The writer also

says (p. 170): "\_On a essayÃ©, mais sans succcÃ¨s, d'y transporter des

grenouilles qui mangent les oeufs que les moustigues deposent sur les eaux

stagnantes.\_" It thus appears that there were then no frogs on the island.

[162] That the dodo is really an abortion from a more perfect type, and not

a direct development from some lower form of wingless bird, is shown by its

possessing a keeled sternum, though the keel is exceedingly reduced, being

only three-quarters of an inch deep in a length of seven inches. The most

terrestrial pigeon--the Didunculus of the Samoan Islands, has a far deeper

and better developed keel, showing that in the case of the dodo the

degradation has been extreme. We have also analogous examples in other

extinct birds of the same group of islands, such as the flightless

Rails--Aphanapteryx of Mauritius and Erythromachus of Rodriguez, as well as

the large parrot--Lophopsittacus of Mauritius, and the Night Heron,

\_Nycticorax megacephala\_ of Rodriguez, the last two birds probably having

been able to fly a little. The commencement of the same process is to be

seen in the peculiar dove of the Seychelles, \_Turtur rostratus\_, which, as

Mr. Edward Newton has shown, has much shorter wings than its close ally,

\_T. picturatus\_, of Madagascar. For a full and interesting account of these

and other recently extinct birds see Professor Newton's article on "Fossil

Birds" in the \_EncyclopÃ¦dia Britannica\_, ninth edition, vol. iii., p. 732;

and that on "The Extinct Birds of Rodriguez," by Dr. A. GÃ¼nther and Mr. E.

Newton, in the Royal Society's volume on the Transit of Venus Expedition.

[163] See \_Ibis\_, 1877, p. 334.

[164] A common Indian and Malayan toad (\_Bufo melanostictus\_) has been

introduced into Mauritius and also some European toads, as I am informed by

Dr. GÃ¼nther.

[165] This brief account of the Madagascar flora has been taken from a very

interesting paper by the Rev. Richard Baron, F.L.S., F.G.S., in the

\_Journal of the Linnean Society\_, Vol. XXV., p. 246; where much information

is given on the distribution of the flora within the island.

[166] It may be interesting to botanists and to students of geographical

distribution to give here an enumeration of the endemic genera of the

\_Flora of the Mauritius and the Seychelles\_, as they are nowhere separately

tabulated in that work.

Aphloia (BixaceÃ¦) 1 sp., a shrub, Maur., Rod., Sey., also

Madagascar.

Medusagyne (TernstrÃ¶miaceÃ¦) 1 sp., a shrub, Seychelles.

Astiria (SterculiaceÃ¦) 1 sp., a shrub, Mauritius.

Quivisia (MeliaceÃ¦) 3 sp., shrubs, Mauritius (2 sp.),

Rodriguez (1 sp.), also Bourbon.

Cossignya (SapindaceÃ¦) 1 sp., a shrub, Mauritius, also Bourbon.

Hornea ,, 1 sp., a shrub, Mauritius.

Stadtmannia ,, 1 sp., a shrub, Mauritius.

Doratoxylon ,, 1 sp., a shrub, Mauritius and Bourbon.

Gagnebina (LeguminosÃ¦) 1 sp., a shrub, Mauritius, also

Madagascar.

Roussea (SaxifragaceÃ¦) 1 sp., a climbing shrub, Mauritius and

Bourbon.

Tetrataxis (LythraceÃ¦) 1 sp., a shrub, Mauritius.

Psiloxylon ,, 1 sp., a shrub, Mauritius and Bourbon.

Mathurina (TurneraceÃ¦) 1 sp., a shrub, Rodriguez.

Foetidia (MyrtaceÃ¦) 1 sp., a tree, Mauritius.

Danais (RubiaceÃ¦) 4 sp., climbing shrubs, Maur. (1 sp.),

Rodr. (1 sp.), also Bourbon and

Madagascar.

Fernelia (RubiaceÃ¦) 1 sp., a shrub, Mauritius and Rodriguez.

Pyrostria ,, 6 sp., shrubs, Mauritius (3 sp.), also

Bourbon and Madagascar.

Scyphochlamys (RubiaceÃ¦) 1 sp., a shrub, Rodriguez.

Myonima ,, 3 sp., shrubs, Mauritius, also Bourbon.

Cylindrocline (CompositÃ¦) 1 sp., a shrub, Mauritius.

Monarrhenus ,, 2 sp., shrubs, Mauritius, also Bourbon

and Madagascar.

Faujasia (CompositÃ¦) 3 sp., shrubs, Mauritius, also Bourbon

and Madagascar.

HeterochÃ¦nia (CampanulaceÃ¦) 1 sp., a shrub, Mauritius, also Bourbon.

Tanulepis (AsclepiadaceÃ¦) 1 sp., a climber, Rodriguez.

Decanema ,, 1 sp., a climber, Mauritius, also

Madagascar.

Nicodemia (LoganiaceÃ¦) 2 sp., shrubs, Mauritius (1 sp.), also

Comoro Islands and Madagascar.

Bryodes (ScrophulariaceÃ¦) 1 sp., herb, Mauritius.

RadamÃ¦a ,, 2 sp., herb, Seychelles (1 sp.), and

Madagascar.

Colea (BignoniaceÃ¦) 10 sp., Mauritius (1 sp.), Seychelles (1

sp.), also Bourbon and Madagascar.

(Shrubs, trees, or climbers.)

Obetia (UrticaceÃ¦) 2 sp., shrubs, Mauritius, Seychelles,

and Madagascar.

Bosquiea (MoreÃ¦) 3 sp., trees, Seychelles (1 sp.), also

Madagascar.

Monimia (MonimiaceÃ¦) 3 sp., trees, Mauritius (2 sp.), also

Bourbon.

Cynorchis (OrchideÃ¦) 3 sp., herb, ter., Mauritius.

Amphorchis ,, 1 sp., herb, ter., Mauritius, also

Bourbon.

Arnottia ,, 2 sp., herb, ter., Mauritius, also

Bourbon.

Aplostellis ,, 1 sp., herb, ter., Mauritius.

Cryptopus ,, 1 sp., herb, Epiphyte, Mauritius, also

Bourbon and Madagascar.

Lomatophyllum (LiliaceÃ¦) 3 sp., shrubs (succulent), Mauritius,

also Bourbon.

Lodoicea (PalmÃ¦) 1 sp., tree, Seychelles.

Latania ,, 3 sp., trees, Mauritius (2 sp.),

Rodriguez, also Bourbon.

Hyophorbe ,, 3 sp., trees, Mauritius (2 sp.),

Rodriguez, also Bourbon.

Dictyosperma ,, 1 sp., tree, Mauritius, Rodriguez,

also Bourbon.

AcanthophÃ¦nix ,, 2 sp., trees, Mauritius, also Bourbon.

Deckenia ,, 1 sp., tree, Seychelles.

Nephrosperma ,, 1 sp., tree, Seychelles.

Roscheria ,, 1 sp., tree, Seychelles.

Verschaffeltia ,, 1 sp., tree, Seychelles.

Stevensonia ,, 1 sp., tree, Seychelles.

Ochropteris (Filices) 1 sp., herb, Mauritius, also Bourbon and

Madagascar.

Among the curious features in this list are the great number of endemic

shrubs in Mauritius, and the remarkable assemblage of five endemic genera

of palms in the Seychelles Islands. We may also notice that one palm

(\_Latania loddigesii\_) is confined to Round Island and two other adjacent

islets offering a singular analogy to the peculiar snake also found there.

[167]

\_Families of Malayan Birds not found in islands East of Celebes.\_

TroglodytidÃ¦.

SittidÃ¦.

ParidÃ¦.

LiotrichidÃ¦.

PhyllornithidÃ¦.

EurylÃ¦midÃ¦.

PicidÃ¦.

IndicatoridÃ¦.

MegalÃ¦nidÃ¦.

TrogonidÃ¦.

PhasianidÃ¦.

\_Families of Moluccan Birds not found in islands West of Celebes.\_

ParadiseidÃ¦.

MeliphagidÃ¦.

CacatuidÃ¦.

PlatycercidÃ¦.

TrichoglossidÃ¦.

NestoridÃ¦.

[168] For outline figures of the chief types of these butterflies, see my

\_Malay Archipelago\_, Vol. I. p. 441, or p. 216 of the tenth edition.

[169] Dobson on the Classification of Chiroptera (\_Ann. and Mag. of Nat.

Hist.\_ Nov. 1875).

[170] See Buller, "On the New Zealand Rat," \_Trans. of the N. Z. Institute\_

(1870), Vol. III. p. 1, and Vol. IX. p. 348; and Hutton, "On the

Geographical Relations of the New Zealand Fauna," \_Trans. N. Z. Instit.\_

1872, p. 229.

[171] Hochstetter's \_New Zealand\_, p. 161, note.

[172] The animal described by Captain Cook as having been seen at

Pickersgill Harbour in Dusky Bay (Cook's 2nd Voyage, Vol. I. p. 98) may

have been the same creature. He says, "A four-footed animal was seen by

three or four of our people, but as no two gave the same description of it,

I cannot say what kind it is. All, however, agreed that it was about the

size of a cat, with short legs, and of a mouse colour. One of the seamen,

and he who had the best view of it, said it had a bushy tail, and was the

most like a jackal of any animal he knew." It is suggestive that, so far as

the points on which "all agreed"--the size and the dark colour--this

description would answer well to the animal so recently seen, while the

"short legs" correspond to the otter-like tracks, and the thick tail of an

otter-like animal may well have appeared "bushy" when the fur was dry. It

has been suggested that it was only one of the native dogs; but as none of

those who saw it took it for a dog, and the points on which they all agreed

are not dog-like, we can hardly accept this explanation; while the actual

existence of an unknown animal in New Zealand of corresponding size and

colour is confirmed by this account of a similar animal having been seen

about a century ago.

[173] Owen, "On the Genus Dinornis," \_Trans. Zool. Soc.\_ Vol. X. p. 184.

Mivart, "On the Axial Skeleton of the StruthionidÃ¦," \_Trans. Zool. Soc.\_

Vol. X. p. 51.

[174] The recent existence of the Moa and its having been exterminated by

the Maoris appears to be at length set at rest by the statement of Mr. John

White, a gentleman who has been collecting materials for a history of the

natives for thirty-five years, who has been initiated by their priests into

all their mysteries, and is said to "know more about the history, habits,

and customs of the Maoris than they do themselves." His information on this

subject was obtained from old natives long before the controversy on the

subject arose. He says that the histories and songs of the Maoris abound in

allusions to the Moa, and that they were able to give full accounts of "its

habits, food, the season of the year it was killed, its appearance,

strength, and all the numerous ceremonies which were enacted by the natives

before they began the hunt, the mode of hunting, how cut up, how cooked,

and what wood was used in the cooking, with an account of its nest, and how

the nest was made, where it usually lived, &c." Two pages are occupied by

these details, but they are only given from memory, and Mr. White promises

a full account from his MSS. Many of the details given correspond with

facts ascertained from the discovery of native cooking places with Moas'

bones; and it seems quite incredible that such an elaborate and detailed

account should be all invention. (See \_Transactions of the New Zealand

Institute\_, Vol. VIII. p. 79.)

[175] See fig. in \_Trans. of N. Z. Institute\_, Vol. III., plate 12\_b.\_ fig.

2.

[176] \_Geographical Distribution of Animals\_, Vol. I., p. 450.

[177] In my \_Geographical Distribution of Animals\_ (I. p. 541) I have given

two peculiar Australian genera (\_Orthonyx\_ and \_Tribonyx\_) as occurring in

New Zealand. But the former has been found in New Guinea, while the New

Zealand bird is considered to form a distinct genus, \_Clitonyx\_; and the

latter inhabits Tasmania, and was recorded from New Zealand through an

error. (See \_Ibis\_, 1873, p. 427.)

[178] The peculiar genera of Australian lizards according to Boulenger's

British Museum Catalogue, are as follows:--Family GECKONIDÃ: Nephrurus,

Rhynchoedura, Heteronota, Diplodactylus, Oedura. Family PYGOPODIDÃ

(peculiar): Pygopus, Cryptodelma, Delma, Pletholax, Aprasia. Family

AGAMIDÃ: Chelosania, Amphibolurus, Tympanocryptis, Diporophora,

Chlamydosaurus, Moloch, Oreodeira. Family SCINCIDÃ: Egerina, Trachysaurus,

HemisphÃ¦nodon. Family doubtful: Ophiopsiseps.

[179] These figures are taken from Mr. G. M. Thomson's address "On the

Origin of the New Zealand Flora," \_Trans. N. Z. Institute\_, XIV. (1881),

being the latest that I can obtain. They differ somewhat from those given

in the first edition, but not so as to affect the conclusions drawn from

them.

[180] This accords with the general scarcity of LeguminosÃ¦ in Oceanic

Islands, due probably to their usually dry and heavy seeds, not adapted to

any of the forms of aÃ«rial transmission; and it would indicate either that

New Zealand was never absolutely united with Australia, or that the union

was at a very remote period when LeguminosÃ¦ were either not differentiated

or comparatively rare.

[181] Sir Joseph Hooker informs me that the number of tropical Australian

plants discovered within the last twenty years is very great, and that the

statement as above made may have to be modified. Looking, however, at the

enormous disproportion of the figures given in the "Introductory Essay" in

1859 (2,200 tropical to 5,800 temperate species) it seems hardly possible

that a great difference should not still exist, at all events as regards

species. In Baron von MÃ¼eller's latest summary of the Australian Flora

(\_Second Systematic Census of Australian Plants\_, 1889), he gives the total

species at 8,839, of which 3,560 occur in West Australia, and 3,251 in New

South Wales. On counting the species common to these two colonies in fifty

pages of the \_Census\_ taken at random, I find them to be about one-tenth of

the total species in both. This would give the number of distinct species

in these areas as about 6,130. Adding to these the species peculiar to

Victoria and South Australia, we shall have a flora of near 6,500 in the

temperate parts of Australia. It is true that West Australia extends far

into the tropics, but an overwhelming majority of the species have been

discovered in the south-western portion of the colony, while the species

that may be exclusively tropical will be more than balanced by those of

temperate Queensland, which have not been taken account of, as that colony

is half temperate and half tropical. It thus appears probable that full

three fourths of the species of Australian plants occur in the temperate

regions, and are mainly characteristic of it. Sir Joseph Hooker also doubts

the generally greater richness of tropical over temperate floras which I

have taken as almost an axiom. He says: "Taking similar areas to Australia

in the Western World, \_e.g.\_, tropical Africa north of 20Â° S. Lat. as

against temperate Africa and Europe up to 47Â°--I suspect that the latter

would present more genera and species than the former." This, however,

appears to me to be hardly a case in point, because Europe is a distinct

continent from Africa and has had a very different past history, and it is

not a fair comparison to take the tropical area in one continent while the

temperate is made up of widely separated areas in two continents. A closer

parallel may perhaps be found in equal areas of Brazil and south temperate

America, or of Mexico and the Southern United States, in both of which

cases I suppose there can be little doubt that the tropical areas are far

the richest. Temperate South Africa is, no doubt, always quoted as richer

than an equal area of tropical Africa or perhaps than any part of the world

of equal extent, but this is admitted to be an exceptional case.

[182] Sir Joseph Hooker thinks that later discoveries in the Australian

Alps and other parts of East and South Australia may have greatly modified

or perhaps reversed the above estimate, and the figures given in the

preceding note indicate that this is so. But still, the small area of

South-west Australia will be, proportionally, far the richer of the two. It

is much to be desired that the enormous mass of facts contained in Mr.

Bentham's \_Flora Australiensis\_ and Baron von MÃ¼eller's \_Census\_ should be

tabulated and compared by some competent botanist, so as to exhibit the

various relations of its wonderful vegetation in the same manner as was

done by Sir Joseph Hooker with the materials available twenty-one years

ago.

[183] From an examination of the fossil corals of the South-west of

Victoria, Professor P. M. Duncan concludes--"that, at the time of the

formation of these deposits the central area of Australia was occupied by

sea, having open water to the north, with reefs in the neighbourhood of

Java." The age of these fossils is not known, but as almost all are extinct

species, and some are almost identical with European Pliocene and Miocene

species, they are supposed to belong to a corresponding period. (\_Journal

of Geol. Soc.\_, 1870.)

[184] "On the Origin of the Fauna and Flora of New Zealand," by Captain

F. W. Hutton, in \_Annals and Mag. of Nat. Hist.\_ Fifth series, p. 427

(June, 1884).

[185] To these must now be added the genera Sequoia, Myrica, Aralia, and

Acer, described by Baron von Ettingshausen. (\_Trans. N.Z. Institute\_, xix.,

p. 449.)

[186] The large collection of fossil plants from the Tertiary beds of New

Zealand which have been recently described by Baron von Ettingshausen

(\_Trans. N. Z. Inst.\_, vol. xxiii., pp. 237-310), prove that a change in

the vegetation has occurred similar to that which has taken place in

Eastern Australia, and that the plants of the two countries once resembled

each other more than they do now. We have, first, a series of groups now

living in Australia, but which have become extinct in New Zealand, as

Cassia, Dalbergia, Eucalyptus, Diospyros, Dryandra, Casuarina, and Ficus;

and also such northern genera as Acer, Planera, Ulmus, Quercus, Alnus,

Myrica, and Sequoia. All these latter, except Ulmus and Planera, have been

found also in the Eastern-Australian Tertiaries, and we may therefore

consider that at this period the northern temperate element in both floras

was identical. If this flora entered both countries from the south, and was

really Antarctic, its extinction in New Zealand may have been due to the

submergence of the country to the south, and its elevation and extension

towards the tropics, admitting of the incursion of the large number of

Polynesian and tropical Australian types now found there; while the

Australian portion of the same flora may have succumbed at a somewhat later

period, when the elevation of the Cretaceous and Tertiary sea united it

with Western Australia, and allowed the rich typical Australian flora to

overrun the country. Of course we are assuming that the identification of

these genera is for the most part correct, though almost entirely founded

on leaves only. Fuller knowledge, both of the extinct flora itself and of

the geological age of the several deposits, is requisite before any

trustworthy explanation of the phenomena can be arrived at.

[187] The following are the tropical genera common to New Zealand and

Australia:--

1. \_Melicope.\_ Queensland, Pacific Islands.

2. \_Eugenia.\_ Eastern and Tropical Australia, Asia, and America.

3. \_Passiflora.\_ N.S.W. and Queensland, Tropics of Old World and America.

4. \_Myrsine.\_ Tropical and Temperate Australia, Tropical and Sub-tropical

regions.

5. \_Sapota.\_ Australia, Norfolk Islands, Tropics.

6. \_Cyathodes.\_ Australia and Pacific Islands.

7. \_Parsonsia.\_ Tropical Australia and Asia.

8. \_Geniostoma.\_ Queensland, Polynesia, Asia.

9. \_Mitrasacme.\_ Tropical and Temperate Australia, India.

10. \_Ipomoea.\_ Tropical Australia, Tropics.

11. \_Mazus.\_ Temperate Australia, India, China.

12. \_Vitex.\_ Tropical Australia, Tropical and Sub-tropical.

13. \_Pisonia.\_ Tropical Australia, Tropical and Sub-tropical.

14. \_Alternanthera.\_ Tropical Australia, India, and S. America.

15. \_Tetranthera.\_ Tropical Australia, Tropics.

16. \_Santalum.\_ Tropical and Sub-tropical Australia, Pacific, Malay

Islands.

17. \_Carumbium.\_ Tropical and Sub-tropical Australia, Pacific Islands.

18. \_Elatostemma.\_ Sub-tropical Australia, Asia, Pacific Islands.

19. \_Peperomia.\_ Tropical and Sub-tropical Australia, Tropics.

20. \_Piper.\_ Tropical and Sub-tropical Australia, Tropics.

21. \_Dacrydium.\_ Tasmania, Malay, and Pacific Islands.

22. \_Dammara.\_ Tropical Australia, Malay, and Pacific Islands.

23. \_Dendrobium.\_ Tropical Australia, Eastern Tropics.

24. \_Bolbophyllum.\_ Tropical and Sub-tropical Australia, Tropics.

25. \_Sarcochilus.\_ Tropical and Sub-tropical Australia, Fiji, and Malay

Islands.

26. \_Freycinetia.\_ Tropical Australia, Tropical Asia.

27. \_Cordyline.\_ Tropical Australia, Pacific Islands.

28. \_Dianella.\_ Australia, India, Madagascar, Pacific Islands.

29. \_Cyperus.\_ Australia, Tropical regions mainly.

30. \_Fimbristylis.\_ Tropical Australia, Tropical regions.

31. \_Paspalum.\_ Tropical and Sub-tropical grasses.

32. \_Isachne.\_ Tropical and Sub-tropical grasses.

33. \_Sporobolus.\_ Tropical and Sub-tropical grasses.

[188] Insects are tolerably abundant in the open mountain regions, but very

scarce in the forests. Mr. Meyrick says that these are "strangely deficient

in insects, the same species occurring throughout the islands;" and Mr.

Pascoe remarked that "the forests of New Zealand were the most barren

country, entomologically, he had ever visited." (\_Proc. Ent. Soc.\_, 1883.

p. xxix.)

[189] Introductory Essay \_On the Flora of Australia\_, p. 130.

[190] Hooker, \_On the Flora of Australia\_, p. 95.--H. C. Watson, in

Godman's \_Azores\_, pp. 278-286.

[191] As this is a point of great interest in its bearing on the dispersal

of plants by means of mountain ranges, I have endeavoured to obtain a few

illustrative facts:--

1. Mr. William Mitten, of Hurstpierpoint, Sussex, informs me that when the

London and Brighton railway was in progress in his neighbourhood,

\_Melilotus vulgaris\_ made its appearance on the banks, remained for several

years, and then altogether disappeared. Another case is that of \_Diplotaxis

muralis\_, which formerly occurred only near the sea-coast of Sussex, and at

Lewes; but since the railway was made has spread along it, and still

maintains itself abundantly on the railway banks though rarely found

anywhere else.

2. A correspondent in Tasmania informs me that whenever the virgin forest

is cleared in that island there invariably comes up a thick crop of a plant

locally known as fire-weed--a species of Senecio, probably \_S. Australis\_.

It never grows except where the fire has gone over the ground, and is

unknown except in such places. My correspondent adds:--"This autumn I went

back about thirty-five miles through a dense forest, along a track marked

by some prospectors the year before, and in one spot where they had camped,

and the fire had burnt the fallen logs, &c., there was a fine crop of

'fire-weed.' All around for many miles was a forest of the largest trees

and dense scrub." Here we have a case in which burnt soil and ashes favour

the germination of a particular plant, whose seeds are easily carried by

the wind, and it is not difficult to see how this peculiarity might favour

the dispersal of the species for enormous distances, by enabling it

temporarily to grow and produce seeds on burnt spots.

3. In answer to an inquiry on this subject, Mr. H. C. Watson has been kind

enough to send me a detailed account of the progress of vegetation on the

railway banks and cuttings about Thames Ditton. This account is written

from memory, but as Mr. Watson states that he took a great interest in

watching the process year by year, there can be no reason to doubt the

accuracy of his memory. I give a few extracts which bear especially on the

subject we are discussing.

"One rather remarkable biennial plant appeared early (the second year, as I

recollect) and renewed itself either two or three years, namely, \_Isatis

tinctoria\_--a species usually supposed, to be one of our introduced, but

pretty well naturalised, plants. The nearest stations then or since known

to me for this \_Isatis\_ are on chalk about Guildford, twenty miles distant.

There were two or three plants of it at first, never more than half a

dozen. Once since I saw a plant of \_Isatis\_ on the railway bank near

Vauxhall.

"Close by Ditton Station three species appeared which may be called

interlopers. The biennial \_Barbarea precox\_, one of these, is the least

remarkable, because it might have come as seed in the earth from some

garden, or possibly in the Thames gravel (used as ballast). At first it

increased to several plants, then became less numerous, and will soon, in

all probability, become extinct, crowded out by other plants. The biennial

\_Petroselinum segetum\_ was at first one very luxuriant plant on the slope

of the embankment. It increased by seed into a dozen or a score, and is now

nearly if not quite extinct. The third species is \_Linaria purpurea\_, not

strictly a British plant, but one established in some places on old walls.

A single root of it appeared on the chalk facing of the embankment by

Ditton Station. It has remained there several years and grown into a

vigorous specimen. Two or three smaller examples are now seen by it,

doubtless sprung from some of the hundreds or thousands of seeds shed by

the original one plant. The species is not included in Salmon and Brewer's

\_Flora of Surrey\_.

"The main line of the railway has introduced into Ditton parish the

perennial \_Arabis hirsuta\_, likely to become a permanent inhabitant. The

species is found on the chalk and greensand miles away from Thames Ditton;

but neither in this parish nor in any adjacent parish, so far as known to

myself or to the authors of the flora of the county, does it occur. Some

years after the railway was made a single root of this \_Arabis\_ was

observed in the brickwork of an arch by which the railway is carried over a

public road. A year or two afterwards there were three or four plants. In

some later year I laid some of the ripened seed-pods between the bricks in

places where the mortar had partly crumbled out. Now there are several

scores of specimens in the brickwork of the arch. It is presumable that the

first seed may have been brought from Guildford. But how could it get on to

the perpendicular face of the brickwork?

"The Bee Orchis (\_Ophrys apifera\_), plentiful on some of the chalk lands in

Surrey, is not a species of Thames Ditton, or (as I presume) of any

adjacent parish. Thus, I was greatly surprised some years back to see about

a hundred examples of it in flower in one clayey field either on the

outskirts of Thames Ditton or just within the limits of the adjoining

parish of Cobham. I had crossed this same field in a former year without

observing the Ophrys there. And on finding it in the one field I closely

searched the surrounding fields and copses, without finding it anywhere

else. Gradually the plants became fewer and fewer in that one field, and

some six or eight years after its first discovery there the species had

quite disappeared again. I guessed it had been introduced with chalk, but

could obtain no evidence to show this."

4. Mr. A. Bennett, of Croydon, has kindly furnished me with some

information on the temporary vegetation of the banks and cuttings on the

railway from Yarmouth to Caistor in Norfolk, where it passes over extensive

sandy Denes with a sparse vegetation. The first year after the railway was

made the banks produced abundance of \_Oenothera odorata\_ and \_Delphinium

Ajacis\_ (the latter only known thirty miles off in cornfields in

Cambridgeshire), with \_Atriplex patula\_ and \_A. deltoidea\_. Gradually the

native sand plants--Carices, Grasses, \_Galium verum\_, &c., established

themselves, and year by year covered more ground till the new introductions

almost completely disappeared. The same phenomenon was observed in

Cambridgeshire between Chesterton and Newmarket, where, the soil being

different, \_Stellaria media\_ and other annuals appeared in large patches;

but these soon gave way to a permanent vegetation of grasses, composites,

&c., so that in the third year no \_Stellaria\_ was to be seen.

5. Mr. T. Kirk (writing in 1878) states that--"in Auckland, where a dense

sward of grass is soon formed, single specimens of the European milk

Thistle (\_Carduus marianus\_) have been known for the past fifteen years;

but although they seeded freely, the seeds had no opportunity of

germinating, so that the thistle did not spread. A remarkable exception to

this rule occurred during the formation of the Onehunga railway, where a

few seeds fell on disturbed soil, grew up and flowered. The railway works

being suspended, the plant increased rapidly, and spread wherever it could

find disturbed soil."

Again:--"The fiddle-dock (\_Rumex pulcher\_) occurs in great abundance on the

formation of new streets, &c., but soon becomes comparatively rare. It

seems probable that it was one of the earliest plants naturalised here, but

that it partially died out, its buried seeds retaining their vitality."

\_Medicago sativa\_ and \_Apium graveolens\_, are also noted as escapes from

cultivation which maintain themselves for a time but soon die out.

(\_Transactions of the New Zealand Institute\_, Vol. X. p. 367.)

The preceding examples of the \_temporary\_ establishment of plants on newly

exposed soil, often at considerable distances from the localities they

usually inhabit, might, no doubt, by further inquiry be greatly multiplied;

but, unfortunately, the phenomenon has received little attention, and is

not even referred to in the elaborate work of De Candolle (\_GÃ©ographie

Botanique RaisonnÃ©e\_) in which almost every other aspect of the dispersion

and distribution of plants is fully discussed. Enough has been advanced,

however, to show that it is of constant occurrence, and from the point of

view here advocated it becomes of great importance in explaining the almost

world-wide distribution of many common plants of the north temperate zone.

[192] Sir Joseph Hooker informs me that he considers these identifications

worthless, and Mr. Bentham has also written very strongly against the value

of similar identifications by Heer and Unger. Giving due weight to the

opinions of these eminent botanists we must admit that Australian genera

have not yet been \_demonstrated\_ to have existed in Europe during the

Tertiary period; but, on the other hand, the evidence that they did so

appears to have some weight, on account of the improbability that the

numerous resemblances to Australian plants which have been noticed by

different observers should \_all\_ be illusory; while the well established

fact of the former wide distribution of many tropical or now restricted

types of plants and animals, so frequently illustrated in the present

volume, removes the antecedent improbability which is supposed to attach to

such identifications. I am myself the more inclined to accept them,

because, according to the views here advocated, such migrations must have

taken place at remote as well as at recent epochs; and the preservation of

some of these types in Australia while they have become extinct in Europe,

is exactly paralleled by numerous facts in the distribution of animals

which have been already referred to in Chapter XIX., and elsewhere in this

volume, and also repeatedly in my larger work.

[193] Out of forty-two genera from the Eocene of Sheppey enumerated by Dr.

Ettingshausen in the \_Geological Magazine\_ for January 1880, only two or

three appear to be extinct, while there is a most extraordinary

intermixture of tropical and temperate forms--Musa, Nipa, and Victoria,

with Corylus, Prunus, Acer, &c. The rich Miocene flora of Switzerland,

described by Professor Heer, presents a still larger proportion of living

genera.

[194] The recent discovery by Lieutenant Jensen of a rich flora on rocky

peaks rising out of the continental ice of Greenland, as well as the

abundant vegetation of the highest northern latitudes, renders it possible

that even now the Antarctic continent may not be wholly destitute of

vegetation, although its climate and physical condition are far less

favourable than those of the Arctic lands. (See \_Nature\_, Vol. XXI. p.

345.)

[195] Dr. Hector notes the occurrence of the genus \_Dammara\_ in Triassic

deposits, while in the Jurassic period New Zealand possessed the genera

\_PalÃ¦ozamia\_, \_Oleandrium\_, \_Alethopteris\_, \_Camptopteris\_, \_Cycadites\_,

\_Echinostrobus\_, &c., all Indian forms of the same age. Neocomian beds

contain a true dicotyledonous leaf with \_Dammara\_ and \_Araucaria\_. The

Cretaceous deposits have produced a rich flora of dicotyledonous plants,

many of which are of the same genera as the existing flora; while the

Miocene and other Tertiary deposits produce plants almost identical with

those now inhabiting the country, together with many North Temperate genera

which have since become extinct. (See p. 499, footnote, and \_Trans. New

Zealand Inst.\_, Vol. XI. 1879, p. 536.)

[196] The fact stated in the last edition of the \_Origin of Species\_ (p.

340) on the authority of Sir Joseph Hooker, that Australian plants are

rapidly sowing themselves and becoming naturalised on the Neilgherrie

mountains in the southern part of the Indian Peninsula, though an exception

to the rule of the inability of Australian plants to become naturalised in

the Northern Hemisphere, is yet quite in harmony with the hypothesis here

advocated. For not only is the climate of the Neilgherries more favourable

to Australian plants than any part of the North Temperate zone, but the

entire Indian Peninsula has existed for unknown ages as an \_island\_ and

thus possesses the "insular" characteristic of a comparatively poor and

less developed flora and fauna as compared with the truly "continental"

Malayan and Himalayan regions. Australian plants are thus enabled to

compete with those of the Indian Peninsula highlands with a fair chance of

success.

\* \* \* \* \*

Corrections made to printed original.

Page 10. "the general stability of continents": 'sontinents' in original.

Pages 35, 250, 361, 363 "oenanthe" read for "Ã¦nanthe" throughout for

consistency

Page 50. "some others of the lower animals": 'animials' in original.

Page 82. "transmission along mountain chains": 'mountains chains' in

original.

Page 99. "our present land masses": 'massses' in original.

Page 149. "the whole earth should theoretically be": 'thoretically' in

original.

Page 200. "the flora and fauna, in the British area": 'Brittish' in

original.

Page 234. "the indications of an uninterrupted warm climate": 'indic-tions'

on line break in original.

Page 306. "artificially removed by man": 'artifically' in original.

Page 346. "Elachista rufocinerea, the larva of which ...": 'lava' in

original.

Page 456. "Cynopithecus nigrescens": 'Cynopitheus' in original.

Footnote 100. "S. B. J. Skertchley": 'S. B. K.' in original. I have left

the name as Skertchley as Wallace uses this spelling almost consistently,

although Skertchly (as on p. 118) appears to be correct.--Tr.

Footnote 105. "the transportation of the plants": 'transporation' in

original.

Footnote 110. "Agriolimax campestris": 'Agriolimaoe' (ligand oe) in

original.