BIOLOGY.

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THE range of subjects comprehended within this Section is so wide, and my own acquaintance with them so imperfect, that it is not in my power to lay before you any general outline of the recent progress of the biological sciences. Neither do I feel competent to give you a summary of the present status of any one of the great divisions of our science, such as Anatomy, Physiology, Embryology, Histology, Classification, or Evolution—Philology, Ethnology, or Prehistoric Archæology; but there are fortunately several outlying and more or less neglected subjects to which I have for some time had my attention directed, and which I hope will furnish matter for a few observations of some interest to biologists, and be at the same time not unintelligible to the less scientific members of the Association who may honour us with their presence.

The subjects I first propose to consider have no general name, and are not easily grouped under a single descriptive heading; but they may be compared with that recent development of a sister science which has been termed Surface-geology or Earth-sculpture. In the older geological works we learnt much about strata, and rocks, and fossils, their superposition, contortions, chemical constitution, and affinities, with some general notions of how they were formed in the remote past; but we often came to the end of the volume no whit the wiser as to how and why the surface of the earth came to be so wonderfully and beautifully diversified; we were not told why some mountains are rounded and others precipitous; why some valleys are wide and open, others narrow and rocky; why rivers so often pierce through mountain-chains; why mountain lakes are often so enormously deep; whence came the gravel, and drift, and erratic blocks so strangely spread over wide areas while totally absent from other areas equally extensive. So long as these questions were almost ignored, geology could hardly claim to be a complete science, because, while professing to explain how the crust of the earth came to be what it is, it gave no intelligible account of the varied phenomena presented by its surface. But of late years these surface-phenomena have been assiduously studied; the marvellous effects of denudation and glacial action in giving the final touches to the actual contour of the earth's surface, and their relation to climatic changes and the antiquity of man, have been clearly traced, thus investing geology with a new and popular interest, and at the same time elucidating many of the phenomena presented in the older formations.

Now just as a surface-geology was required to complete that science, so a surface-biology was wanted to make the science of living things more complete and more generally interesting, by applying the results arrived at by special workers to the interpretation of those external and prominent features whose endless variety and beauty constitute the charm which attracts us to the contemplation or to the study of nature. The descriptive zoologist, for example, gives us the external characters of animals; the anatomist studies their internal structure; the histologist makes known to us the nature of their component tissues; the embryologist patiently watches the progress of their development; the systematist groups them into classes and orders, families, genera, and species; while the field-naturalist studies for us their food and habits and general economy. But till quite recently none of these earnest students, nor all of them combined, could answer satisfactorily, or even attempted to answer, many of the simplest questions concerning the external characters and general relations of animals and plants. Why are flowers so wonderfully varied in form and colour? what causes the Arctic fox and the ptarmigan to turn white in winter? why are there no elephants in America and no deer in Australia? why are closely allied species rarely found together? why are male animals so frequently bright-coloured? why are extinct animals so often larger than those which are now living? what has led to the production of the gorgeous train of the peacock and of the two kinds of flower in the primrose? The solution of

these and a hundred other problems of like nature was rarely approached by the old method of study, or if approached was only the subject of vague speculation. It is to the illustrious author of the 'Origin of Species' that we are indebted for teaching us how to study nature as one great, compact, and beautifully adjusted system. Under the touch of his magic wand the countless isolated facts of internal and external structure of living things—their habits, their colours, their development, their distribution, their geological history,—all fell into their approximate places; and although, from the intricacy of the subject and our very imperfect knowledge of the facts themselves, much still remains uncertain, yet we can no longer doubt that even the minutest and most superficial peculiarities of animals and plants either, on the one hand, are or have been useful to them, or, on the other hand, have been developed under the influence of general laws, which we may one day understand to a much greater extent than we do at present. So great is the alteration effected in our comprehension of nature by the study of variation, inheritance, cross-breeding, competition, distribution, protection, and selection—showing, as they often do, the meaning of the most obscure phenomena and the mutual dependence of the most widely-separated organisms—that it can only be fitly compared with the analogous alteration produced in our conception of the universe by Newton's grand discovery of the law of gravitation.

I know it will be said (and is said) that Darwin is too highly rated, that some of his theories are wholly and others partially erroneous, and that he often builds a vast superstructure on a very uncertain basis of doubtfully interpreted facts. Now, even admitting this criticism to be well founded—and I myself believe that to a limited extent it is so—I nevertheless maintain that Darwin is not and cannot be too highly rated; for his greatness does not at all depend upon his being infallible, but on his having developed, with rare patience and judgment, a new system of observation and study, guided by certain general principles which are almost as simple as gravitation and as wide-reaching in their effects. And if other principles should hereafter be discovered, or if it be proved that some of his subsidiary theories are wholly or partially erroneous, this very discovery can only be made by following in Darwin's steps, by adopting the method of research which he has taught us, and by largely using the rich stores of material which he has collected. The 'Origin of Species,' and the grand series of works which have succeeded it, have revolutionized the study of biology: they have given us new ideas and fertile principles; they have infused life and vigour into our science, and have opened up hitherto unthought-of lines of research on which hundreds of eager students are now labouring. Whatever modifications some of his theories may require, Darwin must none the less be looked up to as the founder of philosophical biology.

As a small contribution to this great subject, I propose now to call your attention to some curious relations of organisms to their environment, which seem to me worthy of more systematic study than has hitherto been given them. The points I shall more especially deal with are—the influence of locality, or of some unknown local causes, in determining the colours of insects, and, to a less extent, of birds; and the way in which certain peculiarities in the distribution of plants may have been brought about by their dependence on insects. The latter part of my address will deal with the present state of our knowledge as to the antiquity and early history of mankind.

On some Relations of Living Things to their Environment.

Of all the external characters of animals, the most beautiful, the most varied, and the most generally attractive are the brilliant colours and strange yet often elegant markings with which so many of them are adorned. Yet of all characters this is the most difficult to bring under the laws of utility or of physical connexion. Mr. Darwin—as you are well aware—has shown how wide is the influence of sex on the intensity of coloration; and he has been led to the conclusion that active or voluntary sexual selection is one of the chief causes, if not the chief cause, of all the variety and beauty of colour we see among the higher animals. This is one of the points on which there is much divergence of opinion even among the supporters of Mr. Darwin, and one as to which I myself differ from him. I have argued, and still believe, that the need of protection is a far more efficient cause of

variation of colour than is generally suspected; but there are evidently other causes at work, and one of these seems to be an influence depending strictly on locality, whose nature we cannot yet understand, but whose effects are everywhere to be seen when carefully searched for.

Although the careful experiments of Sir John Lubbock have shown that insects can distinguish colours—as might have been inferred from the brilliant colours of the flowers which are such an attraction to them—yet we can hardly believe that their appreciation and love of distinctive colours is so refined as to guide and regulate their most powerful instinct—that of reproduction. We are therefore led to seek some other cause for the varied colours that prevail among insects; and as this variety is most conspicuous among butterflies—a group perhaps better known than any other—it offers the best means of studying the subject. The variety of colour and marking among these insects is something marvellous. There are probably about ten thousand different kinds of butterflies now known, and about half of these are so distinct in colour and marking that they can be readily distinguished by this means alone. Almost every conceivable tint and pattern is represented, and the hues are often of such intense brilliance and purity as can be equalled by neither birds nor flowers.

Any help to a comprehension of the causes which may have concurred in bringing about so much diversity and beauty must be of value; and this is my excuse for laying before you the more important cases I have met with of a connexion between colour and locality.

Our first example is from tropical Africa, where we find two unrelated groups of butterflies belonging to two very distinct families (Nymphalidæ and Papilionidæ) characterized by a prevailing blue-green colour not found in any other continent *. Again, we have a group of African Pieridæ which are white or pale yellow with a marginal row of bead-like black spots; and in the same country one of the Lycænidæ (*Leptena crastus*) is coloured so exactly like these that it was at first described as a species of *Pieris*. None of these four groups are known to be in any way specially protected, so that the resemblance cannot be due to protective mimicry.

In South America we have far more striking cases; for in the three subfamilies *Danainæ*, *Acræinæ*, and *Heliconiinæ*, all of which are specially protected, we find identical tints and patterns reproduced, often in the greatest detail, each peculiar type of coloration being characteristic of distinct geographical subdivisions of the continent. Nine very distinct genera are implicated in these parallel changes—*Lycorea*, *Ceratinia*, *Mechanitis*, *Ithomia*, *Melinæa*, *Tithorea*, *Acræa*, *Heliconius*, and *Eueides*, groups of three or four (or even five) of them appearing together in the same livery in one district, while in an adjoining district most or all of them undergo a simultaneous change of coloration or of marking. Thus in the genera *Ithomia*, *Mechanitis*, and *Heliconius* we have species with yellow apical spots in Guiana, all represented by allied species with white apical spots in South Brazil. In *Mechanitis*, *Melinæa*, and *Heliconius*, and sometimes in *Tithorea*, the species of the Southern Andes (Bolivia and Peru) are characterized by an orange and black livery, while those of the Northern Andes (New Granada) are almost always orange-yellow and black. Other changes of a like nature, which it would be tedious to enumerate, but which are very striking when specimens are examined, occur in species of the same groups inhabiting these same localities, as well as Central America and the Antilles. The resemblance thus produced between widely different insects is sometimes general, but often so close and minute that only a critical examination of structure can detect the difference between them. Yet this can hardly be true mimicry, because all are alike protected by the nauseous secretion which renders them unpalatable to birds.

In another series of genera (*Catagramma*, *Callithea*, and *Agrias*), all belonging to the Nymphalidæ, we have the most vivid blue ground, with broad bands of orange-crimson or a different tint of blue or purple, exactly reproduced in corresponding, yet unrelated species, occurring in the same locality; yet, as none of these groups are protected, this can hardly be true mimicry. A few species of two other genera

* *Romalcosoma* and *Euryphene* (Nymphalidæ), *Papilio zalmoxis* and several species of the *Nireus*-group (Papilionidæ).

in the same country (*Eunica* and *Siderone*) also reproduce the same colours, but with only a general resemblance in the marking. Yet, again, in Tropical America we have species of *Apatura* which, sometimes in both sexes, sometimes in the female only, exactly imitate the peculiar markings of another genus (*Heterochroa*) confined to America: here, again, neither genus is protected, and the similarity must be due to unknown local causes.

But it is among islands that we find some of the most striking examples of the influence of locality on colour, generally in the direction of paler, but sometimes of darker and more brilliant hues, and often accompanied by an unusual increase of size. Thus in the Moluccas and New Guinea we have several Papilios (*P. euchenor*, *P. ormenus*, and *P. tydeus*) distinguished from their allies by a much paler colour, especially in the females, which are almost white. Many species of *Danais* (forming the subgenus *Ideopsis*) are also very pale. But the most curious are the Euplœas, which in the larger islands are usually of rich dark colours, while in the small islands of Banda, Ké, and Matabello at least three species not nearly related to each other (*E. hoppferi*, *E. euripon*, and *E. assimilata*) are all broadly banded or suffused with white, their allies in the larger islands being all very much darker. Again, in the genus *Diadema*, belonging to a distinct family, three species from the small Aru and Ké islands (*D. devis*, *D. hewitsonii*, and *D. polymena*) are all more conspicuously white-marked than their representatives in the larger islands. In the beautiful genus *Cethosia*, a species from the small island of Waigiou (*C. cyrene*) is the whitest of the genus. *Prothoë* is represented by a blue species in the continental island of Java, while those inhabiting the ancient insular groups of the Moluccas and New Guinea are all pale yellow or white. The genus *Drusilla*, almost confined to these islands, comprises many species which are all very pale; while in the small island of Waigiou is found a very distinct genus, *Hyantis*, which, though differing completely in the neuration of the wings, has exactly the same pale colours and large ocellated spots as *Drusilla*. Equally remarkable is the fact that the small island of Amboina produces larger-sized butterflies than any of the larger islands which surround it. This is the case with at least a dozen butterflies belonging to many distinct genera*, so that it is impossible to attribute it to other than some local influence. In Celebes, as I have elsewhere pointed out†, we have a peculiar form of wing and much larger size running through a whole series of distinct butterflies; and this seems to take the place of any speciality in colour.

From the Fiji Islands we have comparatively few butterflies; but there are several species of *Diadema* of unusually pale colours, some almost white.

The Philippine Islands seem to have the peculiarity of developing metallic colours. We find there at least three species of *Euplœa*‡ not closely related, and all of more intense metallic lustre than their allies in other islands. Here also we have one of the large yellow *Ornithopteræ* (*O. magellanus*), whose hind wings glow with an intense opaline lustre not found in any other species of the entire group; and an *Adolias*§ is larger and of more brilliant metallic colouring than any other species in the archipelago. In these islands also we find the extensive and wonderful genus of weevils (*Pachyrhynchus*), which in their brilliant metallic colouring surpass any thing found in the whole eastern hemisphere, if not in the whole world.

In the Andaman Islands in the Bay of Bengal there are a considerable number of peculiar species of butterflies differing slightly from those on the continent, and generally in the direction of paler or more conspicuous colouring. Thus two species of *Papilio* which on the continent have the tails black, in their Andaman representatives have them either red- or white-tipped ‖. Another species ¶ is richly blue-banded where its allies are black; while three species of distinct genera of

* *Ornithoptera priamus*, *O. helena*, *Papilio deiphobus*, *P. ulysses*, *P. gambrisius*, *P. codrus*, *Iphias leucippe*, *Euplœa prothoë*, *Hestia idea*, *Athyma jocaste*, *Diadema pandarus*, *Nymphalis pyrrhus*, *N. euryalus*, *Drusilla jairus*.

† 'Contributions to the Theory of Natural Selection,' pp. 168–173.

‡ *Euplœa hewitsonii*, *E. diocletiana*, *E. lætifica*.

§ *Adolias calliphorus*.

‖ *Papilio rhodifer* (near *P. doubledayi*) and *Papilio charicles* (near *P. memnon*).

¶ *Papilio mayo*.

Nymphalidæ* all differ from their allies on the continent in being of excessively pale colours as well as of somewhat larger size.

In Madagascar we have the very large and singularly white-spotted *Papilio antenor*, while species of three other genera† are very white or conspicuous compared with their continental allies.

Passing to the West-Indian Islands and Central America (which latter country has formed a group of islands in very recent times) we have similar indications. One of the largest of the Papilios inhabits Jamaica ‡, while another, the largest of its group, is found in Mexico §. Cuba has two of the same genus whose colours are of surpassing brilliancy ‖ ; while the fine genus *Clothilda*—confined to the Antilles and Central America—is remarkable for its rich and showy colouring.

Persons who are not acquainted with the important structural differences that distinguish these various genera of butterflies can hardly realize the importance and the significance of such facts as I have now detailed. It may be well, therefore, to illustrate them by supposing parallel cases to occur among the Mammalia. We might have, for example, in Africa, the gnus, the elands, and the buffaloes, all coloured and marked like zebras, stripe for stripe over the whole body exactly corresponding. So the hares, marmots, and squirrels of Europe might be all red with black feet, while the corresponding species of Central Asia were all yellow with black heads. In North America we might have raccoons, squirrels, and opossums in parti-coloured livery of white and black, so as exactly to resemble the skunk of the same country ; while in South America they might be black with a yellow throat-patch, so as to resemble with equal closeness the tayra of the Brazilian forests. Were such resemblances to occur in any thing like the number and with the wonderful accuracy of imitation met with among the Lepidoptera, they would certainly attract universal attention among naturalists, and would lead to the exhaustive study of the influence of local causes in producing such startling results.

One somewhat similar case does indeed occur among the Mammalia, two singular African animals, the Aard-wolf (*Proteles*) and the hyæna-dog (*Lycaon*), both strikingly resembling hyænas in their general form as well as in their spotted markings. Belonging as they all do to the Carnivora, though to three distinct families, it seems quite an analogous case to those we have imagined ; but as the Aard-wolf and the hyæna-dog are both weak animals compared with the hyæna, the resemblance may be useful, and in that case would come under the head of mimicry. This seems the more probable because, as a rule, the colours of the Mammalia are protective, and are too little varied to allow of the influence of local causes producing any well-marked effects.

When we come to birds, however, the case is different ; for although they do not exhibit such distinct marks of the influence of locality as do butterflies—probably because the causes which determine colour are in their case more complex—yet there are distinct indications of some effect of the kind, and we must devote some little time to their consideration.

One of the most curious cases is that of the parrots of the West-Indian Islands and Central America, several of which have white heads or foreheads, occurring in two distinct genera ¶, while none of the more numerous parrots of South America are so coloured. In the small island of Dominica we have a very large and richly-coloured parrot (*Chrysotis augusta*) corresponding to the large and richly-coloured *Papilio homerus* of Jamaica.

The Andaman Islands are equally remarkable, at least six of the peculiar birds differing from their continental allies in being much lighter, and sometimes with a large quantity of pure white in the plumage**, exactly corresponding to what occurs among the butterflies.

In the Philippines this is not so marked a feature ; yet we have here :—the only known white-breasted kingcrow (*Dicrurus mirabilis*) ; the newly discovered *Eury-*

* *Euplœa andamanensis, Cethosia biblis, Cyrestis cocles.*

† *Danais nossima, Melanitis massoura, Diadema dexithea.*

‡ *Papilio homerus.* § *P. daunus.* ‖ *P. gundlachianus, P. villiersi.*

¶ *Pionus albifrons* and *Chrysotis senilis* (C. America), *Chrysotis salleei* (Hayti).

** *Kittacincla albiventris, Geocichla albigularis, Sturna andamanensis, Hyloterpe grisola,* var., *Ianthœnas palumboides, Osmotreron chloroptera.*

lamus Steerii, wholly white beneath; three species of *Dicæum*, all white beneath; several species of *Parus*, largely white-spotted; while many of the pigeons have light ashy tints. The birds generally, however, have rich dark colours, similar to those which prevail among the butterflies.

In Celebes we have a swallow-shrike and a peculiar small crow allied to the jackdaw *, whiter than any of their allies in the surrounding islands; but otherwise the colours of the birds call for no special remark.

In Timor and Flores we have white-headed pigeons †, and a long-tailed fly-catcher almost entirely white ‡.

In the small Lord Howe's Island we have the recently extinct white rail (*Notornis alba*), remarkably contrasting with its allies in the larger islands of New Zealand.

We cannot, however, lay any stress on isolated examples of white colour, since these occur in most of the great continents; but where we find a series of species of distinct genera all differing from their continental allies in a whiter coloration, as in the Andaman Islands and the West Indies, and, among butterflies, in the smaller Moluccas, the Andamans, and Madagascar, we cannot avoid the conclusion that in these insular localities some general cause is at work.

There are other cases, however, in which local influences seem to favour the production or preservation of intense crimson or a very dark coloration. Thus in the Moluccas and New Guinea alone we have bright red parrots belonging to two distinct families §, and which therefore most probably have been independently produced or preserved by some common cause. Here, too, and in Australia we have black parrots and pigeons ‖; and it is a most curious and suggestive fact that in another insular subregion—that of Madagascar and the Mascarene Islands—these same colours reappear in the same two groups ¶.

Some very curious physiological facts bearing upon the presence or absence of white colours in the higher animals have lately been adduced by Dr. Ogle **. It has been found that a coloured or dark pigment in the olfactory region of the nostrils is essential to perfect smell, and this pigment is rarely deficient except when the whole animal is pure white. In these cases the creature is almost without smell or taste. This, Dr. Ogle believes, explains the curious case of the pigs in Virginia adduced by Mr. Darwin, white pigs being killed by a poisonous root which does not affect black pigs. Mr. Darwin imputed this to a constitutional difference accompanying the dark colour, which rendered what was poisonous to the white-coloured animals quite innocuous to the black. Dr. Ogle, however, observes that there is no proof that the black pigs eat the root, and he believes the more probable explanation to be that it is distasteful to them; while the white pigs, being deficient in smell and taste, eat it and are killed. Analogous facts occur in several distinct families. White sheep are killed in the Tarentino by eating *Hypericum crispum*, while black sheep escape; white rhinoceroses are said to perish from eating *Euphorbia candelabrum*; and white horses are said to suffer from poisonous food where coloured ones escape. Now it is very improbable that a constitutional immunity from poisoning by so many distinct plants should, in the case of such widely different animals, be always correlated with the same difference of colour; but the facts are readily understood if the senses of smell and taste are dependent on the presence of a pigment which is deficient in wholly white animals. The explanation has, however, been carried a step further, by experiments showing that the absorption of odours by dead matter, such as clothing, is greatly affected by colour, black being the most powerful absorbent; then blue, red, yellow, and lastly white. We have here a physical cause for the sense-inferiority of totally white animals which may account for their rarity in nature: for few, if any, wild animals are wholly white: the head, the face, or at least the muzzle or the nose, are generally black; the ears and eyes are also often black; and there is reason to believe that dark pigment is essential to good hearing, as it certainly

* *Artamus monachus*, *Corvus advena*.
† *Ptilopus cinctus*, *P. albocinctus*.
‡ *Tchitrea affinis*, var.
§ *Lorius*, *Eos* (Trichoglossidæ), *Eclectus* (Palæornithidæ).
‖ *Microglossus*, *Calyptorhynchus*, *Turacæna*.
¶ *Coracopsis*, *Alectrænas*.
** Medico-Chirurgical Transactions, vol. liii. (1870).

is to perfect vision. We can therefore understand why white cats with blue eyes are so often deaf, a peculiarity we notice more readily than their deficiency of smell or taste.

If, then, the prevalence of white coloration is generally accompanied with some deficiency in the acuteness of the most important senses, this colour becomes doubly dangerous; for it not only renders its possessor more conspicuous to its enemies, but at the same time makes it less ready in detecting the presence of danger. Hence, perhaps, the reason why white appears more frequently in islands, where competition is less severe and enemies less numerous and varied. Hence, also, a reason why *albinoism*, although freely occurring in captivity, never maintains itself in a wild state, while *melanism* does. The peculiarity of some islands in having all their inhabitants of dusky colours (as the Galapagos) may also perhaps be explained on the same principles; for poisonous fruits or seeds may there abound which weed out all white- or light-coloured varieties, owing to their deficiency of smell and taste. We can hardly believe, however, that this would apply to white-coloured butterflies; and this may be a reason why the effect of an insular habitat is more marked in these insects than in birds or mammals. But though inapplicable to the lower animals, this curious relation of sense-acuteness with colours may have had some influence on the development of the higher human races. If light tints of the skin were generally accompanied by some deficiency in the senses of smell, hearing and vision, the white could never compete with the darker races so long as man was in a very low or savage condition, and wholly dependent for existence on the acuteness of his senses. But as the mental faculties became more fully developed and more important to his welfare than mere sense-acuteness, the lighter tints of skin and hair and eyes would cease to be disadvantageous whenever they were accompanied by superior brain-power. Such variations would then be preserved; and thus may have arisen the Xanthochroic race of mankind, in which we find a high development of intellect accompanied by a slight deficiency in the acuteness of the senses as compared with the darker forms.

I have now to ask your attention to a few remarks on the peculiar relations of plants and insects as exhibited in islands.

Ever since Mr. Darwin showed the immense importance of insects in the fertilization of flowers great attention has been paid to the subject, and the relation of these two very different classes of natural objects has been found to be more universal and more complex than could have been anticipated. Whole genera and families of plants have been so modified as first to attract, and then to be fertilized by, certain groups of insects; and this special adaptation seems in many cases to have determined the more or less wide range of the plants in question. It is also known that some species of plants can be fertilized only by particular species of insects; and the absence of these from any locality would necessarily prevent the continued existence of the plant in that area. Here, I believe, will be found the clue to much of the peculiarity of the floras of oceanic islands, since the methods by which these have been stocked with plants and insects will be often quite different. Many seeds are, no doubt, carried by oceanic currents, others probably by aquatic birds. Mr. H. N. Moseley informs me that the albatrosses, gulls, puffins, tropic birds, and many others nest inland, often amidst dense vegetation, and he believes they often carry seeds, attached to their feathers, from island to island for great distances. In the tropics they often nest on the mountains far inland, and may thus aid in the distribution even of mountain-plants. Insects, on the other hand, are mostly conveyed by aerial currents, especially by violent gales; and it may thus often happen that totally unrelated plants and insects may be brought together, in which case the former must often perish for want of suitable insects to fertilize them. This will, I think, account for the strangely fragmentary nature of these insular floras, and the great differences that often exist between those which are situated in the same ocean, as well as for the preponderance of certain orders and genera. In Mr. Pickering's valuable work on the 'Geographical Distribution of Animals and Plants,' he gives a list of no less than sixty-six natural orders of plants *unexpectedly* absent from Tahiti, or which occur in many of the surrounding lands, some being abundant in other islands—as the Labiatæ at the Sandwich Islands. In these latter islands the flora is much richer, yet a large number of

families which abound in other parts of Polynesia are totally wanting. How much of the poverty and exceptional distribution of the plants of these islands is probably due to the great scarcity of flower-frequenting insects. Lepidoptera and Hymenoptera are exceedingly scarce in the eastern islands of the Pacific, and it is almost certain that many plants which require these insects for their fertilization have been thereby prevented from establishing themselves. In the western islands, such as the Fijis, several species of butterflies occur in tolerable abundance, and no doubt some flower-haunting Hymenoptera accompany them; and in these islands the flora appears to be much more varied, and especially to be characterized by a much greater variety of showy flowers, as may be seen by examining the plates of Dr. Seemann's 'Flora Vitiensis.'

Darwin and Pickering both speak of the great preponderance of ferns at Tahiti; and Mr. Moseley, who spent several days in the interior of the island, informs me that "at an elevation of from 2000 to 3000 feet the dense vegetation is composed almost entirely of ferns. A tree fern (*Alsophila tahitensis*) forms a sort of forest to the exclusion of almost every other tree, and, with huge plants of two other ferns (*Angiopteris evecta* and *Aspelenium nidus*), forms the main mass of the vegetation." And he adds, "I have nowhere seen ferns in so great proportionate abundance." This unusual proportion of ferns is a general feature of insular as compared with continental floras; but it has, I believe, been generally attributed to favourable conditions, especially to equable climate and perennial moisture. In this respect, however, Tahiti can hardly differ greatly from many other islands, which yet have no such vast preponderance of ferns. This is a question that cannot be decided by mere lists of species, since it is probable that in Tahiti they are less numerous than in some other islands where they form a far less conspicuous feature in the vegetation. The island most comparable with Tahiti in that respect is Juan Fernandez. Mr. Moseley writes to me:—"In a general view of any wide stretch of the densely clothed mountainous surface of the island, the ferns, both tree ferns and the unstemmed forms, are seen at once to compose a very large proportion of the mass of foliage." As to the insects of Juan Fernandez, Mr. Edwyn C. Reed, who made two visits and spent several weeks there, has kindly furnished me with some exact information. Of butterflies there is only one (*Pyrameis carie*), and that rare—a Chilian species, and probably an accidental straggler. Four species of moths of moderate size were observed (all Chilian), and a few larvæ and pupæ. Of bees there were none, except one very minute species (allied to *Chilicola*), and of other Hymenoptera a single specimen of *Ophion luteus* (a cosmopolitan ichneumon). About twenty species of flies were observed, and these formed the most prominent feature of the entomology of the island.

Now, as far as we know, this extreme entomological poverty agrees closely with that of Tahiti; and there are probably no other portions of the globe equally favoured in soil and climate, and with an equally luxuriant vegetation, where insect-life is so scantily developed. It is curious, therefore, to find that these two islands also agree in the wonderful predominance of ferns over the flowering plants —in individuals even more than in species; and there is no difficulty in connecting the two facts. The excessive minuteness and great abundance of fern-spores causes them to be far more easily distributed by winds than the seeds of flowering plants, and they are thus always ready to occupy any vacant places in suitable localities, and to compete with the less vigorous flowering plants. But where insects are so scarce, all plants which require insect-fertilization, whether constantly to enable them to produce seed at all, or occasionally to keep up their constitutional vigour by crossing, must be at a great disadvantage; and thus the scanty flora which oceanic islands must always possess, peopled as they usually are by waifs and strays from other lands, is rendered still more scanty by the weeding out of all such as depend largely on insect-fertilization for their full development. It seems probable, therefore, that the preponderance of ferns in islands (considered in mass of individuals rather than in number of species) is largely due to the absence of competing phænogamous plants, and that this is in great part due to the scarcity of insects. In other oceanic islands, such as New Zealand and the Galapagos, where ferns, although tolerably abundant, form no such predominant feature in the vegetation, but where the scarcity of flower-haunting insects is almost equally

marked, we find a great preponderance of small, green, or otherwise inconspicuous flowers, indicating that only such plants have been enabled to flourish there as are independent of insect-fertilization. In the Galapagos (which are perhaps even more deficient in flying insects than Juan Fernandez) this is so striking a feature that Mr. Darwin speaks of the vegetation as consisting in great part of "wretched-looking weeds," and states that "it was some time before he discovered that almost every plant was in flower at the time of his visit." He also says that he "did not see one beautiful flower" in the islands. It appears, however, that Compositæ, Leguminosæ, Rubiaceæ, and Solanaceæ form a large proportion of the flowering plants; and as these are orders which usually require insect-fertilization, we must suppose, either that they have become modified so as to be self-fertilized, or that they are fertilized by the visits of the minute Diptera and Hymenoptera, which are the only insects recorded from these islands.

In Juan Fernandez, on the other hand, there is no such total deficiency of showy flowers. I am informed by Mr. Moseley that a variety of the Magnoliaceous winter-bark abounds and has showy white flowers, and that a Bignoniaceous shrub with abundance of dark blue flowers was also plentiful; while a white-flowered Liliaceous plant formed large patches on the hill-sides. Besides these there were two species of woody Compositæ with conspicuous heads of yellow blossoms, and a species of white-flowered myrtle also abundant; so that, on the whole, flowers formed a rather conspicuous feature in the aspect of the vegetation of Juan Fernandez.

But this fact—which at first sight seems entirely at variance with the view we are upholding of the important relation between the distribution of insects and plants—is well explained by the existence of two species of humming-birds in Juan Fernandez, which, in their visits to these large and showy flowers, fertilize them as effectually as bees, moths, or butterflies. Mr. Moseley informs me that "these humming-birds are *extraordinarily abundant*, every tree or bush having one or two darting about it." He also observed that "nearly all the specimens killed had the feathers round the base of the bill and front of the head clogged and coloured yellow with pollen." Here, then, we have the clue to the perpetuation of large and showy flowers in Juan Fernandez; while the total absence of humming-birds in the Galapagos may explain why no such large-flowered plants have been able to establish themselves in those equatorial islands.

This leads to the observation that many other groups of birds also, no doubt, aid in the fertilization of flowers. I have often observed the beaks and faces of the brush-tongued lories of the Moluccas covered with pollen; and Mr. Moseley noted the same fact in a species of *Artamus*, or swallow-shrike, shot at Cape York, showing that this genus also frequents flowers and aids in their fertilization. In the Australian region we have the immense group of the Meliphagidæ, which all frequent flowers; and as these range over all the islands of the Pacific, their presence will account for a certain proportion of showy flowers being found there, such as the scarlet *Metrosideros*, one of the few conspicuous flowers in Tahiti. In the Sandwich Islands, too, there are forests of *Metrosideros*; and Mr. Charles Pickering writes me, that they are visited by honey-sucking birds, one of which is captured by sweetened bird-lime, against which it thrusts its extensile tongue. I am also informed that a considerable number of flowers are occasionally fertilized by humming-birds in North America; so that there can, I think, be little doubt that birds play a much more important part in this respect than has hitherto been imagined. It is not improbable that in Tropical America, where the humming-bird family is so enormously developed, many flowers will be found to be expressly adapted to fertilization by them, just as so many in our own country are specially adapted to the visits of certain families or genera of insects.

It must also be remembered, as Mr. Moseley has suggested to me, that a flower which had acquired a brilliant colour to attract insects might, on transference to another country, and becoming so modified as to be capable of self-fertilization, retain the coloured petals for an indefinite period. Such is probably the explanation of the *Pelargonium* of Tristan d'Acunha, which forms masses of bright colour near the shore during the flowering season; while most of the other plants of the island have colourless flowers, in accordance with the almost total absence of winged insects. The presence of many large and showy flowers among the indigenous

flora of St. Helena must be an example of a similar persistence. Mr. Melliss indeed states it to be "a remarkable peculiarity that the indigenous flowers are, with very slight exceptions, all perfectly colourless;"* but although this may apply to the general aspect of the remains of the indigenous flora, it is evidently not the case as regards the *species*, since the interesting plates of Mr. Melliss's volume show that about one third of the indigenous flowering plants have more or less coloured or conspicuous flowers, while several of them are exceedingly showy and beautiful. Among these are a *Lobelia*, three *Wahlenbergias*, several *Compositæ*, and especially the handsome red flowers of the now almost extinct forest-trees, the ebony and redwood (species of *Melhania*, Byttneriaceæ). We have every reason to believe, however, that when St. Helena was covered with luxuriant forests, and especially at that remote period when it was much more extensive than it is now, it must have supported a certain number of indigenous birds and insects, which would have aided in the fertilization of these gaily-coloured flowers. The researches of Dr. Hermann Müller have shown us by what minute modifications of structure or of function many flowers are adapted for partial insect- and self-fertilization in various degrees; so that we have no difficulty in understanding how, as the insects diminished and finally disappeared, self-fertilization may have become the rule, while the large and showy corollas remain to tell us plainly of a once different state of things.

Another interesting fact in connexion with this subject is the presence of arborescent forms of Compositæ in so many of the remotest oceanic islands. They occur in the Galapagos, in Juan Fernandez, in St. Helena, in the Sandwich Islands, and in New Zealand; but they are not directly related to each other, representatives of totally different tribes of this extensive order becoming arborescent in each group of islands. The immense range and almost universal distribution of the Compositæ is due to the combination of a great facility of distribution (by their seeds) with a great attractiveness to insects, and the capacity of being fertilized by a variety of species of all orders, and especially by flies and small beetles. Thus they would be among the earliest of flowering plants to establish themselves on oceanic islands; but where insects of all kinds were very scarce it would be an advantage to gain increased size and longevity, so that fertilization at an interval of several years might suffice for the continuance of the species. The arborescent form would combine with increased longevity the advantage of increased size in the struggle for existence with ferns and other early colonists; and these advantages have led to its being independently produced in so many distant localities, whose chief feature in common is their remoteness from continents and the extreme poverty of their insect life.

As the sweet odours of flowers are known to act in combination with their colours, as an attraction to insects, it might be anticipated that where colour was deficient scent would be so also. On applying to my friend Dr. Hooker for information as to New-Zealand plants, he informed me that this was certainly the case, and that the New-Zealand flora is, speaking generally, as strikingly deficient in sweet odours as in conspicuous colours. Whether this peculiarity occurs in other islands, I have not been able to obtain information; but we may certainly expect it to be so in such a marked instance as that of the Galapagos flora.

Another question which here comes before us is the origin and meaning of the odoriferous glands of leaves. Dr. Hooker informed me that not only are New-Zealand plants deficient in scented flowers, but equally so in scented leaves. This led me to think that perhaps such leaves were in some way an additional attraction to insects—though it is not easy to understand how this could be, except by adding a general attraction to the special attraction of the flowers, or by supporting the larvæ which, as perfect insects, aid in fertilization. Mr. Darwin, however, informs me that he considers that leaf-glands bearing essential oils are a protection against the attacks of insects where these abound, and would thus not be required in countries where insects were very scarce. But it seems opposed to this view that highly aromatic plants are characteristic of deserts all over the world, and in such places insects are not abundant. Mr. Stainton informs me that the aromatic Labiatæ enjoy no immunity from insect attacks. The bitter leaves of the cherry-

* Melliss's 'St. Helena,' p. 226, note.

laurel are often eaten by the larvæ of moths that abound on our fruit-trees; while in the Tropics the leaves of the orange tribe are favourites with a large number of lepidopterous larvæ; and our northern firs and pines, although abounding in a highly aromatic resin, are very subject to the attacks of beetles. My friend Dr. Richard Spruce—who while travelling in South America allowed nothing connected with plant-life to escape his observation—informs me that trees whose leaves have aromatic and often resinous secretions in immersed glands abound in the plains of tropical America, and that such are in great part, if not wholly, free from the attacks of leaf-eating ants, except where the secretion is only slightly bitter, as in the orange tribe, orange-trees being sometimes entirely denuded of their leaves in a single night. Aromatic plants abound in the Andes up to about 13,000 feet, as well as in the plains, but hardly more so than in Central and Southern Europe. They are perhaps more plentiful in the dry mountainous parts of Southern Europe; and as neither here nor in the Andes do leaf-eating ants exist, Dr. Spruce infers that, although in the hot American forests where such ants swarm the oil-bearing glands serve as a protection, yet they were not originally acquired for that purpose. Near the limits of perpetual snow on the Andes such plants as occur are not, so far as Dr. Spruce has observed, aromatic; and as plants in such situations can hardly depend on insect visits for their fertilization, the fact is comparable with that of the flora of New Zealand, and would seem to imply some relation between the two phenomena, though what it exactly is cannot yet be determined.

I trust I have now been able to show you that there are a number of curious problems lying as it were on the outskirts of biological inquiry which well merit attention, and which may lead to valuable results. But these problems are, as you see, for the most part connected with questions of locality, and require full and accurate knowledge of the productions of a number of small islands and other limited areas, and the means of comparing them the one with the other. To make such comparisons, however, is now quite impossible. No museum contains any fair representations of the productions of these localities; and such specimens as do exist, being scattered through the general collection, are almost useless for this special purpose. If, then, we are to make any progress in this inquiry, it is absolutely essential that some collectors should begin to arrange their cabinets primarily on a geographical basis, keeping together the productions of every island or group of islands, and of such divisions of each continent as are found to possess any special or characteristic fauna or flora. We shall then be sure to detect many unsuspected relations between the animals and plants of certain localities, and we shall become much better acquainted with those complex reactions between the vegetable and animal kingdoms, and between the organic world and the inorganic, which have almost certainly played an important part in determining many of the most conspicuous features of living things.

Rise and Progress of Modern Views as to the Antiquity and Origin of Man.

I now come to a branch of our subject which I would gladly have avoided touching on; but as the higher powers of this Association have decreed that I should preside over the Anthropological Department, it seems proper that I should devote some portion of my address to matters more immediately connected with the special study to which that Department is devoted.

As my own knowledge of and interest in Anthropology is confined to the great outlines rather than to the special details of the science, I propose to give a very brief and general sketch of the modern doctrine as to the Antiquity and Origin of Man, and to suggest certain points of difficulty which have not, I think, yet received sufficient attention.

Many now present remember the time (for it is little more than twenty years ago) when the antiquity of man, as now understood, was universally discredited. Not only theologians, but even geologists, then taught us that man belonged altogether to the existing state of things; that the extinct animals of the Tertiary period had finally disappeared, and that the earth's surface had assumed its present condition before the human race first came into existence. So prepossessed were