zoic have long held their places from the reluctance to disturb established nomenclature, as well as from the difficulty of inventing appropriate substitutes; but if retained at all, we know now that the relations they represent are not the same for the terrestrial, the deep oceanic, and the intermediate areas, any more than the life is the same under those three conditions.

I have once before called attention to a grave difficulty in the physical geography of Scotland; and as Mr. Seeley has since then raised the same question without obtaining an answer, I would again state the case as one which seems to involve the revisal of some definitions.

The Silurian hills of South Scotland are commonly said to have been covered by Old Red Sandstone and even by Carboniferous strata, patches of these rocks being met with on the south side of the fault which defines these hills with their abrupt, coast-like margin seen from Edinburgh, or from Symington station on the Caledonian line. But the surface of these Silurians was denuded before the Old Red times, as Mr. Geikie has showed. Nay, valleys existed as now, and in the same positions as now. At the present time the rivers flow in identically the same valleys, in at least the cases of the Nith, the Annan, the Lauder, and the Liddell; and the boundaries of the areas are so well known that we can safely assert no buried channel to exist such as we find on the tributaries of the Clyde. That the channels were occluded in glacial times we may take for certain; that the obstruction has been washed away and the courses cleared is equally certain. The surface contours were not materially altered, so that the retreating ice left hollows in the position of the old valleys. But the case is quite different when we deal with the older rocks. Their succession is marked by unconformities and overlaps, which it is impossible to picture as associated with full preservation of the surface features on which they were laid down; and when the thickness comes to be as much as 1,000 feet or more, and of that thickness a part at least made up of marine strata, the relapse of all the streams to their old causes is an event of the highest improbability. Mr. Topley has pointed out how the dip of strata may, under certain circumstances, coincide with their thinning out to the margins of their area of deposit, changes of angle in highly inclined strata pointing in the same direction. The ordinary rule of protracting strata, and thus restoring their thickness over the adjacent high ground, is, in the case, at least, of South Scotland, a method which imposes on atmospheric denudation, even if aided by the sea, a most complicated task.

Had time permitted, it might have been interesting to note the changing phraseology regarding faults, and the pertinacity with which phrases involving the most unsatisfactory and improbable causation continue to be used. Upcast and downcast, upthrow and downthrow, displacement upwards or downwards—these it may be said are of small importance; they are only symbols. But in the first place they are mischievous so far as they give students confused ideas with which to contend, and in the second place the continued acceptance of loose phraseology is peculiar to geology; even in metaphysics, where the subject matter is much more conveniently discussed in ordinary language, new terms are employed to a great extent. But important as I therefore regard these terms from the teacher's point of view, the greater importance attaches to the accuracy of the notions which underlie our language regarding the processes and rates of deposit and denudation.

So far as our present knowledge goes, we must accept it as certain that there is some limit to the duration of the earth in the past. Neither philosophers nor astronomers are agreed on the essential points of the problem, nor have they considered all the possible changes in the position of the earth's axis, and in the rate at which the earth loses heat. The limits hitherto prescribed are so discrepant that we cannot as yet accept any as fixed. Neither have geologists so accurate a knowledge of geological processes that they can speak with confidence either of the absolute or relative rates at which rock formation has advanced. The geologist has hitherto asked for more time, not because he himself was aware of his need, but from a generous regard for the difficulties in which his zoological brother found himself when he attempted to explain the diversity of the animal series as the result of slowly-operating causes. The geologist asked for more time simply because he could form no just estimate of what was needed for the physical processes with whose results he was familiar. But palæontological domination is now at an end; and the increasing number of geologists, who are also competent physicists and mathematicians, seems to mark a new school, which will strive to interpret more precisely the accumulated facts. Such at least seems the history of the past fifteen or twenty years. Such seems the direction in which speculation now tends, and in the foregoing remarks I have endeavoured faithfully to represent the drift of our science. To many here present much of what I have said is already familiar; I therefore give place to the more legitimate business of the Section, looking to receive elsewhere "such censures as may be my lot."

SECTION D.

BIOLOGY.

OPENING ADDRESS BY THE PRESIDENT, ALFRED RUSSEL WALLACE.

Introduction.

THE range of subjects comprehended within this Section is so wide, and my own acquaintance with them so imperfect and fragmentary, 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 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 [illegible] 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. We have the descriptive zoologist, for example, who gives us the external characters of animals; the anatomist studies their internal structure; the histologist makes known 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 revolutionised 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 connection. Mr. Darwin—as you are well aware—has shown how wide is the influence of sex on the intensity of colouration; 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 connection 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) characterised by a prevailing blue green colour not found in any other continent.[1] 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 (*Liptena erastus*) 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 sub-families—Danainæ, Acræniæ, 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 of 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 characterised by an orange and black livery, while those of the Northern Andes (New Grenada) 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 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.

[1] *Romaleosoma* and *Eurypheme* (Nymphalidæ), *Papilio zalmoxis*, and several species of the *Nireus* group (Papilionidæ).

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 sub-genus *Ideopsis*) are also very pale. But the most curious are the Euplæas, 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. deois*, *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. *Prothoe* 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,[1] so that it is impossible to attribute it to other than some local influence. In Celebes, as I have elsewhere pointed out,[2] 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 specialty 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 *Euplæa*[3] 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*[4] 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 anything 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.[5] Another species[6] is richly blue-banded where its allies are black; while three species of distinct genera of Nymphalidæ[7] 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[8] 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,[9] while another, the largest of its group, is found in Mexico.[1] Cuba has two of the same genus whose colours are of surpassing brilliancy;[2] 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 realise 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 anything 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,[3] 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,[4] 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 *Eurylæmus 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,[5] 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,[6] and a long-tailed flycatcher almost entirely white.[7]

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,

[1] *Ornithoptera priamus*, *O. helena*, *Papilio deiphobus*, *P. ulysses*, *P. gambrisius*, *P. codrus*, *Iphias leucippe*, *Euplæa prothöe*, *Hestia idea*, *Athyma jocaste*, *Diadema pandarus*, *Nymphalis pyrrhus*, *N. euryalus*, *Drusilla jairus*.

[2] "Contributions to the Theory of Natural Selection," pp. 168–173.

[3] *Euplæa hewitsonii*, *E. diocletiana*, *E. lætifica*, *E. dupresnii*.

[4] *Adolias calliphorus*.

[5] *Papilio rhodifer* (near *P. doubledayi*) and *Papilio charicles* (near *P. memnon*).

[6] *Papilio mayo*.

[7] *Euplæa andamanensis*, *Cethosia biblis*, *Cyrestis cocles*.

[8] *Danais nossima*, *Melanitis massoura*, *Diadema dexithea*.

[9] *Papilio homerus*.

[1] *P. daunus*.

[2] *P. gundlachianus*, *P. villiersi*.

[3] *Pionus albifrons* and *Chrysotis senilis* (C. America), *Chrysotis sallei* (Hayti).

[4] *Kittacincla albiventris*, *Geocichla albigularis*, *Sturnia andamanensis*, *Hyloterpe grisola*, var., *Janthænas palumboides*, *Osmotreron chloroptera*.

[5] *Artamus monachus*, *Corvus advena*.

[6] *Ptilopus cinctus*, *P. albocinctus*.

[7] *Tchitrea affinis*, var.

but where we find a series of species of distinct genera, all differing from their continental allies in a whiter colouration, 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 colouration. Thus in the Moluccas and New Guinea alone we have bright red parrots belonging to two distinct families,[1] 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;[2] and it is a most curious and suggestive fact that in another insular sub-region—that of Madagascar and the Mascarene Islands—these same colours reappear in the same two groups.[3]

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.[4] 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 poisoned 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 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 colouration 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 aërial 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 fertilise 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. Now 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. Seeman'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 2,000 to 3,000 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

[1] *Lorius, Eos* (Trichoglossidæ), *Eclectus* (Palæornithidæ).
[2] *Microglossus, Calyptorhynchus, Turacæna.*
[3] *Corncopsis, Alectrænas.*
[4] Medico-Chirurgical Transactions, vol. liii. (1870).

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 fertilisation, 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 fertilisation 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 phenogamous 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 fertilisation. 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 fertilisation, we must suppose either that they have become modified so as to be self-fertilised, or that they are fertilised 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's 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 fertilise 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 fertilisation. 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 fertilised 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 [illegible] America, where this family is so enormously developed, many flowers will be found to be expressly adapted to fertilisation 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-fertilisation, retain the coloured petals for an indefinite period. Such is probably the explanation of the *Pelargonium* of Kerguelen's land, 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;"[1] 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 fertilisation 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-fertilisation in varying degrees, so that we have no difficulty in understanding how, as the insects diminished and finally disappeared, self-fertilisation 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 connection 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),

[1] Melliss's *St. Helena*, p. 226, note.

with a great attractiveness to insects, and the capacity of being fertilised 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 the 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 [illegible] of the flowers, or by supporting the larvæ which as [illegible] acts aid in fertilisation. Mr. Darwin, however, informs [illegible] 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-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 most 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 fertilisation, 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 is, however, now quite impossible. No museum contains any fair representation 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 even scientific men with this idea—which yet rested on purely negative evidence, and could not be supported by any arguments of scientific value —that numerous facts which had been presented at intervals for half a century, all tending to prove the existence of man at very remote epochs, were silently ignored; and, more than this, the detailed statements of three distinct and careful observers were rejected by a great scientific Society as too improbable for publication, only because they proved (if they were true) the coexistence of man with extinct animals![1]

But this state of belief in opposition to facts could not long continue. In 1859 a few of our most eminent geologists examined for themselves into the alleged occurrence of flint implements in the gravels of the North of France, which had been made public fourteen years before, and found them strictly correct. The caverns of Devonshire were about the same time carefully examined by equally eminent observers, and were found fully to bear out the statements of those who had published their results eighteen years before. Flint implements began to be found in all suitable localities in the South of England, when carefully searched for, often in gravels of equal antiquity with those of France. Caverns, giving evidence of human occupation at various remote periods, were explored in Belgium and the South of France,—lake dwellings were examined in Switzerland —refuse heaps in Denmark—and thus a whole series of remains have been discovered carrying back the history of mankind from the earliest historic periods to a long distant past. The antiquity of the races thus discovered can only be generally determined by the successively earlier and earlier stages through which we can trace them. As we go back, metals soon disappear and we find only tools and weapons of stone and of bone. The stone weapons get ruder and ruder; pottery, and then the bone implements, cease to occur; and in the earliest stage we find only chipped flints, of rude design though still of unmistakably human workmanship. In like manner domestic animals disappear as we go backward; and though the dog seems to have been the earliest, it is doubtful whether the makers of the ruder flint implements of the gravels possessed even this. Still more important as a measure of time are the changes of the earth's surface—of the distribution of animals—and of climate—which have occurred during the human period. At a comparatively recent epoch in the record of prehistoric times we find that the Baltic was far salter than it is now, and produced abundance of oysters; and that Denmark

[1] In 1854 (?) a communication from the Torquay Natural History Society confirming previous accounts by Mr. Godwin-Austen, Mr. Vivian, and the Rev. Mr. McEnery, that worked flints occurred in Kent's Hole with remains of extinct species, was rejected as too improbable for publication.

was covered with pine forests inhabited by Capercailzies, such as now only occur further north in Norway. A little earlier we find that reindeer were common even in the South of France, and still earlier this animal was accompanied by the mammoth and woolly rhinoceros, by the arctic glutton, and by huge bears and lions of extinct species. The presence of such animals implies a change of climate, and both in the caves and gravels we find proofs of a much colder climate than now prevails in Western Europe. Still more remarkable are the changes of the earth's surface which have been effected during man's occupation of it. Many extensive valleys in England and France are believed by the best observers to have been deepened at least a hundred feet;—caverns now far out of the reach of any stream must for a long succession of years have had streams flowing through them, at least in times of floods—and this often implies that vast masses of solid rock have since been worn away. In Sardinia land has risen at least 300 feet since men lived there who made pottery and probably used fishing-nets;[1] while in Kent's Cavern remains of man are found buried beneath two separate beds of stalagmite, each having a distinct texture, and each covering a deposit of cave-earth having well-marked differential characters, while each contains a distinct assemblage of extinct animals.

Such, briefly, are the results of the evidence that has been rapidly accumulating for about fifteen years as to the antiquity of man; and it has been confirmed by so many discoveries of a like nature in all parts of the globe, and especially by the comparison of the tools and weapons of prehistoric man with those of modern savages, so that the use of even the rudest flint implements has become quite intelligible,—that we can hardly wonder at the vast revolution effected in public opinion. Not only is the belief in man's vast and still unknown antiquity universal among men of science, but it is hardly disputed by any well-informed theologian; and the present generation of science-students must, we should think, be somewhat puzzled to understand, what there was in the earliest discoveries that should have aroused such general opposition and been met with such universal incredulity.

But the question of the mere "Antiquity of Man" almost sank into insignificance at a very early period of the inquiry, in comparison with the far more momentous and more exciting problem of the development of man from some lower animal form, which the theories of Mr. Darwin and of Mr. Herbert Spencer soon showed to be inseparably bound up with it. This has been, and to some extent still is, the subject of fierce conflict; but the controversy as to the fact of such development is now almost at an end, since one of the most talented representatives of Catholic theology, and an anatomist of high standing—Professor Mivart—fully adopts it as regards physical structure, reserving his opposition for those parts of the theory, which would deduce man's whole intellectual and moral nature from the same source, and by a similar mode of development.

Never, perhaps, in the whole history of science or philosophy has so great a revolution in thought and opinion been effected as in the twelve years from 1859 to 1871, the respective dates of publication of Mr. Darwin's "Origin of Species" and "Descent of Man." Up to the commencement of this period the belief in the independent creation or origin of the species of animals and plants, and the very recent appearance of man upon the earth, were, practically, universal. Long before the end of it these two beliefs had utterly disappeared, not only in the scientific world, but almost equally so among the literary and educated classes generally. The belief in the independent origin of man held its ground somewhat longer, but the publication of Mr. Darwin's great work gave even that its death-blow, for hardly anyone capable of judging of the evidence now doubts the derivative nature of man's bodily structure as a whole, although many believe that his mind and even some of his physical characteristics may be due to the action of other forces than have acted in the case of the lower animals.

We need hardly be surprised, under these circumstances, if there has been a tendency among men of science to pass from one extreme to the other, from a profession (so few years ago) of total ignorance as to the mode of origin of all living things, to a claim to almost complete knowledge, of the whole progress of the universe, from the first speck of living protoplasm up to the highest development of the human intellect. Yet this is really what we have seen in the last sixteen years. Formerly difficulties were exaggerated, and it was asserted that we had not sufficient knowledge to venture on any generalizations on the subject. Now difficulties are set aside, and it is held that our theories are so well established and so far-reaching, that they explain and comprehend all nature. It is not long ago (as I have already reminded you) since *facts* were contemptuously ignored because they favoured our now popular views; at the present day it seems to me that facts which oppose them hardly receive due consideration. And as opposition is the best incentive to progress, and it is not well even for the best theories to have it all their own way, I propose to direct your attention to a few such facts, and to the conclusions that seem fairly deducible from them.

It is a curious circumstance, that notwithstanding the attention that has been directed to the subject in every part of the world, and the numerous excavations connected with railways and mines which have offered such facilities for geological discovery, no advance whatever has been made for a considerable number of years, in detecting the time or the mode of man's origin. The Palæolithic flint weapons first discovered in the North of France more than thirty years ago, are still the oldest undisputed proofs of man's existence; and amid the countless relics of a former world that have been brought to light, no evidence of any one of the links that must have connected man with the lower animals has yet appeared.

It is, indeed, well known that negative evidence in geology is of very slender value, and this is, no doubt, generally the case. The circumstances here are, however, peculiar, for many converging lines of evidence show that on the theory of development by the same laws which have determined the development of the lower animals, man must be immensely older than any traces of him yet discovered. As this is a point of great interest we must devote a few moments to its consideration.

1. The most important difference between man and such of the lower animals as most nearly approach him, is undoubtedly in the bulk and development of his brain, as indicated by the form and capacity of the cranium. We should therefore anticipate that these earliest races, who were contemporary with the extinct animals and used rude stone weapons, would show a marked deficiency in this respect. Yet the oldest known crania—those of the Engis and Cro-Magnon caves—show no marks of degradation. The former does not present so low a type as that of most existing savages, but is—to use the words of Prof. Huxley—"of an average human skull, which might have belonged to a philosopher, or might have contained the thoughtless brains of a savage." The latter are still more remarkable, being unusually large and well formed. Dr. Pruner-Bey states that they surpass the average of modern European skulls in capacity, while their symmetrical forms, without any trace of prognathism, compares favourably not only with the foremost savage races, but with many civilised nations of modern times.

One or two other crania of much lower type, but of less antiquity than this, have been discovered; but they in no way invalidate the conclusion which so highly developed a form at so early a period implies, viz., that we have as yet made a hardly perceptible step towards the discovery of any earlier stage in the development of man.

2. This conclusion is supported and enforced by the nature of many of the works of art found even in the oldest cave-dwellings. The flints are of the old chipped type, but they are formed into a large variety of tools and weapons—such as scrapers, awls, hammers, saws, lances, &c., implying a variety of purposes for which these were used, and a corresponding degree of mental activity and civilisation. Numerous articles of bone have also been found, including well-formed needles, implying that skins were sewn together, and perhaps even textile materials woven into cloth. Still more important are the numerous carvings and drawings representing a variety of animals, including horses, reindeer, and even a mammoth, executed with considerable skill on bone, reindeer-horns, and mammoth-tusks. These, taken together, indicate a state of civilisation much higher than that of the lowest of our modern savages, while it is quite compatible with a considerable degree of mental advancement, and leads us to believe that the crania of Engis and Cro-Magnon are not exceptional, but fairly represent the characters of the race. If we further remember that these people lived in Europe under the unfavourable conditions of a sub-Arctic climate, we shall be inclined to agree with Dr. Daniel Wilson, that it is far easier to produce evidences of deterioration than of progress in instituting a comparison between the contemporaries of the mammoth and later prehistoric races of Europe or savage nations of modern times.[2]

3. Yet another important line of evidence as to the extreme

[1] Lyell's Antiquity of Man, fourth edition, p. 113.

[2] "Prehistoric Man," 3rd ed. vol. i. p. 113.

antiquity of the human type has been brought prominently forward by Prof. Mivart.[1] He shows by a careful comparison of all parts of the structure of the body, that man is related, not to any one, but almost equally to many of the existing apes—to the orang, the chimpanzee, the gorilla, and even to the gibbons—in a variety of ways; and these relations and differences are so numerous and so diverse that on the theory of evolution the ancestral form which ultimately developed into man must have diverged from the common stock whence all these various forms and their extinct allies originated. But so far back as the Miocene deposits of Europe, we find the remains of apes allied to these various forms, and especially to the gibbons, so that in all probability the special line of variation which led up to man branched off at a still earlier period. And these early forms, being the initiation of a far higher type, and having to develop by natural selection into so specialised and altogether distinct a creature as man, must have risen at a very early period into the position of a dominant race, and spread in dense waves of population over all suitable portions of the great continent—for this, on Mr. Darwin's hypothesis, is essential to rapid developmental progress through the agency of natural selection.

Under these circumstances we might certainly expect to find some relics of these earlier forms of man along with those of animals which were presumably less abundant. Negative evidence of this kind is not very weighty, but still it has *some* value. It has been suggested that as apes are mostly tropical, and anthropoid apes are now confined almost exclusively to the vicinity of the equator, we should expect the ancestral forms also to have inhabited these same localities—West Africa and the Malay Islands. But this [illegible] is hardly valid, because existing anthropoid apes are dependent on a perennial supply of easily accessible fruits, which is only found near the equator, while not only had the south of Europe an almost tropical climate in Miocene times, but we must suppose even the earliest ancestors of man to have been terrestrial and omnivorous, since it must have taken ages of slow modification to have produced the perfectly erect form, the short arms, and the wholly non-prehensile foot, which so strongly differentiate man from the apes.

The conclusion which I think we must arrive at is, that if man has been developed from a common ancestor, with all existing apes, *and by no other agencies than such as have affected their development*, then he must have existed in something approaching his present form, during the tertiary period—and not merely existed, but predominated in numbers, wherever suitable conditions prevailed. If then, continued researches in all parts of Europe and Asia fail to bring to light any proofs of his presence, it will be at least a presumption that he came into existence at a much later date, and by a much more rapid process of development. In that case it will be a fair argument, that, just as he is in his mental and moral nature, his capacities and aspirations, so infinitely raised above the brutes, so his origin is due to distinct and higher agencies than such as have affected their development.

There is yet another line of inquiry bearing upon this subject to which I wish to call your attention. It is a somewhat curious fact, that, while all modern writers admit the great antiquity of man, most of them maintain the very recent development of his intellect, and will hardly contemplate the possibility of men equal in mental capacity to ourselves, having existed in prehistoric times. This question is generally assumed to be settled, by such relics as have been preserved of the manufactures of the older races showing a lower and lower state of the arts; by the successive disappearance in early times of iron, bronze, and pottery; and by the ruder forms of the older flint implements. The weakness of this argument has been well shown by Mr. Albert Mott in his very original, but little known presidential address to the Literary and Philosophical Society of Liverpool in 1873. He maintains that "our most distant glimpses of the past are still of a world peopled as now with men both civilised and savage"—and, "that we have often entirely misread the past by supposing that the outward signs of civilisation must always be the same, and must be such as are found among ourselves." In support of this view he adduces a variety of striking facts and ingenious arguments, a few of which I will briefly summarise.

On one of the most remote islands of the Pacific—Easter Island—2,000 miles from South America, 2,000 from the Marquesas, and more than 1,000 from the Gambier Islands, are found hundreds of gigantic stone images, now mostly in ruins, often thirty or forty feet high, while some seem to have been much larger, the crowns on their heads cut out of a red stone being sometimes ten feet in diameter, while even the head and neck of one is said to have been twenty feet high.[1] These once stood erect on extensive stone platforms, yet the island has only an area of about thirty square miles, or considerably less than Jersey. Now as one of the smallest images eight feet high weighs four tons, the largest must weigh over a hundred tons, if not much more; and the existence of such vast works implies a large population, abundance of food, and an established government. Yet how could these coexist in a mere speck of land wholly cut off from the rest of the world? Mr. Mott maintains that this necessarily implies the power of regular communication with larger islands or a continent, the arts of navigation, and a civilisation much higher than now exists in any part of the Pacific. Very similar remains in other islands scattered widely over the Pacific add weight to this argument.

The next example is that of the ancient mounds and earthworks of the North American continent, the bearing of which is even more significant. Over the greater part of the extensive Mississippi valley four well-marked classes of these earthworks occur. Some are camps, or works of defence, situated on bluffs, promontories, or isolated hills; others are vast inclosures in the plains and lowlands, often of geometric forms, and having attached to them roadways or avenues often miles in length; a third are mounds corresponding to our tumuli, often seventy to ninety feet high, and some of them covering acres of ground; while a fourth group consist of representations of various animals modelled in relief on a gigantic scale, and occurring chiefly in an area somewhat to the north-west of the other classes, in the plains of Wisconsin.

The first class—the camps or fortified inclosures—resemble in general features the ancient camps of our own islands, but far surpass them in extent. Fort Hill, in Ohio, is surrounded by a wall and ditch a mile and a half in length, part of the way cut through solid rock. Artificial reservoirs for water were made within it, while at one extremity, on a more elevated point, a keep is constructed with its separate defences and water-reservoirs. Another, called Clark's Work, in the Scioto valley, which seems to have been a fortified town, incloses an area of 127 acres, the embankments measuring three miles in length, and containing not less than three million cubic feet of earth. This area incloses numerous sacrificial mounds and symmetrical earthworks in which many interesting relics and works of art have been found.

The second class—the sacred inclosures—may be compared for extent and arrangement with Avebury or Carnak—but are in some respects even more remarkable. One of these, at Newark, Ohio, covers an area of several miles with its connected groups of circles, octagons, squares, ellipses, and avenues, on a grand scale, and formed by embankments from twenty to thirty feet in height. Other similar works occur in different parts of Ohio, and by accurate survey it is found not only that the circles are true, though some of them are one-third of a mile in diameter, but that other figures are truly square, each side being over 1,000 feet long, and what is still more important, the dimensions of some of these geometrical figures in different parts of the country and seventy miles apart, are identical. Now this proves the use, by the builders of these works, of some standard measures of length, while the accuracy of the squares, circles, and, in a less degree, of the octagonal figures—shows a considerable knowledge of rudimentary geometry, and some means of measuring angles. The difficulty of drawing such figures on a large scale is much greater than any one would imagine who has not tried it, and the accuracy of these is far beyond what is necessary to satisfy the eye. We must therefore impute to these people the wish to make these figures as accurate as possible, and this wish is a greater proof of habitual skill and intellectual advancement than even the ability to draw such figures. If, then, we take into account this ability and this love of geometric truth, and further consider the dense population and civil organisation implied by the construction of such extensive systematic works, we must allow that these people had reached the earlier stages of a civilisation of which no traces existed among the savage tribes who alone occupied the country when first visited by Europeans.

The animal mounds are of comparatively less importance for our present purpose, as they imply a somewhat lower grade of advancement; but the sepulchral and sacrificial mounds exist in vast numbers, and their partial exploration has yielded a quantity of articles and works of art, which throw some further light on the peculiarities of this mysterious people. Most of these mounds

[1] "Man and Apes," pp. 171–193.

[1] Journ. of Roy. Geog. Soc., 1870, pp. 177, 178.

contain a large concave hearth or basin of burnt clay, of perfectly symmetrical form, on which are found deposited more or less abundant relics, all bearing traces of the action of fire. We are, therefore, only acquainted with such articles as are practically fire-proof. These consist of bone and copper implements and ornaments, discs, and tubes—pearl, shell, and silver beads, more or less injured by the fire—ornaments cut in mica, ornamental pottery, and numbers of elaborate carvings in stone, mostly forming pipes for smoking. The metallic articles are all formed by hammering, but the execution is very good; plates of mica are found cut into scrolls and circles; the pottery, of which very few remains have been found, is far superior to that of any of the Indian tribes, since Dr. Wilson is of opinion that they must have been formed on a wheel, as they are often of uniform thickness throughout (sometimes not more than one-sixth of an inch) polished, and ornamented with scrolls and figures of birds and flowers in delicate relief. But the most instructive objects are the sculptured stone pipes, representing not only various easily recognisable animals, but also human heads, so well executed that they appear to be portraits. Among the animals not only are such native forms as the panther, bear, otter, wolf, beaver, raccoon, heron, crow, turtle, frog, rattlesnake, and many others, well represented, but also the manatee, which perhaps then ascended the Mississippi as it now does the Amazon, and the toucan, which could hardly have been obtained nearer than Mexico. The sculptured heads are especially remarkable, because they present to us the features of an intellectual and civilised people. The nose in some is perfectly straight, and neither prominent nor dilated, the mouth is small, and the lips thin, the chin and upper lip are short, contrasting with the ponderous jaw of the modern Indian, while the cheek-bones present no marked prominence. Other examples have the nose somewhat projecting at the apex in a manner quite unlike the features of any American indigenes, and, although there are some which show a much coarser face, it is very difficult to see in any of them that close resemblance to the Indian type which these sculptures have been said to exhibit. The few authentic crania from the mounds present corresponding features, being far more symmetrical and better developed in the frontal region than those of any American tribes, although somewhat resembling them in the occipital outline;[1] while one was described by its discoverer (Mr. W. Marshall Anderson) as "a beautiful skull worthy of a Greek."

The antiquity of this remarkable race may perhaps not be very great, as compared with the prehistoric man of Europe, although the opinions of some writers on the subject seem affected by that "parsimony of time" on which the late Sir Charles Lyell so often dilated. The mounds are all overgrown with dense forest, and one of the large trees was estimated to be eight hundred years old, while other observers consider the forest growth to indicate an age of at least 1,000 years. But it is well known that it requires several generations of trees to pass away before the growth on a deserted clearing comes to correspond with that of the surrounding virgin forest, while this forest, once established, may go on growing for an unknown number of thousands of years. The 800 or 1,000 years estimate from the growth of existing vegetation is a minimum which has no bearing whatever on the actual age of these mounds, and we might almost as well attempt to determine the time of the glacial epoch from the age of the pines or oaks which now grow on the moraines.

The important thing for us, however, is that when North America was first settled by Europeans, the Indian tribes inhabiting it had no knowledge or tradition of any preceding race of higher civilisation than themselves. Yet we find that such a race existed; that they must have been populous and have lived under some established government; while there are signs that they practised agriculture largely, as indeed they must have done to have supported a population capable of executing such gigantic works in such vast profusion—for it is stated that the mounds and earthworks of various kinds in the state of Ohio alone amounts to between eleven and twelve thousand. In their habits, customs, religion, and arts, they differed strikingly from all the Indian tribes; while their love of art and of geometric forms, and their capacity for executing the latter upon so gigantic a scale, render it probable that they were a really civilised people, although the form their civilisation took may have been very different from that of later people subject to very different influences, and the inheritors of a longer series of ancestral civilisations. We have here, at all events, a striking example of the transition, over an extensive country, from comparative civilisation to comparative barbarism, the former having left no tradition, and hardly any trace of influence on the latter.

[1] Wilson's "Prehistoric Man," 3rd ed. vol. ii. pp. 123-130.

As Mr. Mott well remarks:—Nothing can be more striking than the fact that Easter Island and North America both give the same testimony as to the origin of the savage life found in them; although in all circumstances and surroundings the two cases are so different. If no stone monuments had been constructed in Easter Island, or mounds, containing a few relics saved from fire, in the United States, we might never have suspected the existence of these ancient peoples. He argues, therefore, that it is very easy for the records of an ancient nation's life entirely to perish, or to be hidden from observation. Even the arts of Nineveh and Babylon were unknown only a generation ago, and we have only just discovered the facts about the mound-builders of North America.

But other parts of the American continent exhibit parallel phenomena. Recent investigations show that in Mexico, Central America, and Peru, the existing race of Indians has been preceded by a distinct and more civilised race. This is proved by the sculptures of the ruined cities of Central America, by the more ancient terra-cottas and paintings of Mexico, and by the oldest portrait-pottery of Peru. All alike show markedly non-Indian features, while they often closely resemble modern European types. Ancient crania, too, have been found in all these countries, presenting very different characters from those of any of the modern indigenous races of America.[1]

There is one other striking example of a higher being succeeded by a lower degree of knowledge, which is in danger of being forgotten because it has been made the foundation of theories which seem wild and fantastic, and are probably in great part erroneous. I allude to the Great Pyramid of Egypt, whose form, dimensions, structure, and uses have recently been the subject of elaborate works by Prof. Piazzi Smyth. Now, the admitted facts about this pyramid are so interesting and so appropriate to the subject we are considering, that I beg to recall them to your attention. Most of you are aware that this pyramid has been carefully explored and measured by successive Egyptologists, and that the dimensions have lately become capable of more accurate determination owing to the discovery of some of the original casing-stones and the clearing away of the earth from the corners of the foundation, showing the sockets in which the corner-stones fitted. Prof. Smyth devoted many months of work with the best instruments in order to fix the dimensions and angles of all accessible parts of the structure; and he has carefully determined these by a comparison of his own and all previous measures, the best of which agree pretty closely with each other. The results arrived at are—

1. That the pyramid is truly square, the sides being equal and the angles right angles.

2. That the four sockets on which the four first stones of the corners rested are truly on the same level.

3. That the direction of the sides are accurately to the four cardinal points.

4. That the vertical height of the pyramid bears the same proportion to its circumference at the base, as the radius of a circle does to its circumference.

Now all these measures, angles, and levels are accurate, not as an ordinary surveyor or builder could make them, but to such a degree as requires the very best modern instruments and all the refinements of geodetical science to discover any error at all. In addition to this we have the wonderful perfection of the workmanship in the interior of the pyramid, the passages and chambers being lined with huge blocks of stones fitted with the utmost accuracy, while every part of the building exhibits the highest structural science.

In all these respects this largest pyramid surpasses every other in Egypt. Yet it is universally admitted to be the oldest, and also the oldest historical building in the world.

Now these admitted facts about the Great Pyramid are surely remarkable, and worthy of the deepest consideration. They are facts which, in the pregnant words of the late Sir John Herschel, "according to received theories ought not to happen," and which, he tells us, should therefore be kept ever present to our minds, since "they belong to the class of facts which serve as the clue to new discoveries." According to modern theories, the higher civilisation is ever a growth and an outcome from a preceding lower state; and it is inferred that this progress is visible to us throughout all history and in all the material records of human intellect. But here we have a building which marks the

[1] Wilson's "Prehistoric Man," 3rd ed. vol. ii. pp. 125, 144.

very dawn of history—which is the oldest authentic monument of man's genius and skill, and which, instead of being far inferior, is very much superior to all which followed it. Great men are the products of their age and country, and the designer and constructors of this wonderful monument could never have arisen among an unintellectual and half-barbarous people. So perfect a work implies many preceding less perfect works which have disappeared. It marks the culminating point of an ancient civilisation, of the early stages of which we have no record whatever.

The three cases to which I have now adverted (and there are many others) seem to require for their satisfactory interpretation a somewhat different view of human progress from that which is now generally accepted. Taken in connection with the great intellectual power of the ancient Greeks—which Mr. Galton believes to have been far above that of the average of any modern nation—and the elevation, at once intellectual and moral, displayed in the writings of Confucius, Zoroaster, and the Vedas, they point to the conclusion, that, while in material progress there has been a tolerably steady advance, man's intellectual and moral development reached almost its highest level in a very remote past. The lower, the more animal, but often the more energetic types, have however always been far the more numerous; hence such established societies as have here and there arisen under the guidance of higher minds, have always been liable to be swept away by the incursions of barbarians. Thus in almost every part of the globe there may have been a long succession of partial civilisation, each in turn succeeded by a period of barbarism; and this view seems supported by the occurrence of degraded types of skull along with such "as might have belonged to a philosopher"—at a time when the mammoth and the reindeer inhabited southern France.

Nor need we fear that there is not time enough for the rise and decay of so many successive civilisations as this view would imply: for the opinion is now gaining ground among geologists that [illegible]olithic man was really preglacial, and that the great [illegible] like by a change of physical conditions, and of animal life—which in Europe always separates him from his neolithic successor, was caused by the coming on and passing away of the great ice age.

If the views now advanced are correct, many, perhaps most, of our existing savages, are the successors of higher races; and their arts, often showing a wonderful similarity in distant continents, may have been derived from a common source among more civilised peoples.

I must now conclude this very imperfect sketch of a few of the offshoots from the great tree of Biological study. It will, perhaps, be thought by some that my remarks have tended to the depreciation of our science, by hinting at imperfections in our knowledge and errors in our theories, where more enthusiastic students see nothing but established truths. But I trust that I may have conveyed to many of my hearers a different impression. I have endeavoured to show that even in what are usually considered the more trivial and superficial characters presented by natural objects, a whole field of new inquiry is opened up to us by the study of distribution and local conditions. And as regards man, I have endeavoured to fix your attention on a class of facts which indicate that the course of his development has been far less direct and simple than has hitherto been supposed; and that, instead of resembling a single tide with its advancing and receding ripples, it must rather be compared to the progress from neap to spring tides, both the rise and the depression being comparatively greater as the waters of true civilisation slowly advance towards the highest level they can reach.

And if we are thus led to believe that our present knowledge of nature is somewhat less complete than we have been accustomed to consider it, this is only what we might expect; for however great may have been the intellectual triumphs of the nineteenth century, we can hardly think so highly of its achievements as to imagine that, in somewhat less than twenty years, we have passed from complete ignorance to almost perfect knowledge on two such vast and complex subjects as the origin of species and the antiquity of man.

SECTION E.

GEOGRAPHY.

OPENING ADDRESS BY F. J. EVANS, C.B., F.R.S., CAPTAIN R.N., PRESIDENT.

Two events, notable in the annals of Geographical Science have to be recorded since the last meeting of the British Association; and these events as bearing materially on the advancement of our knowledge of geography are deserving the special commendation of this Section. I refer to the successful issue of Cameron's land journey across the tropical regions of Southern Africa and to the successful completion of the sea voyage of the *Challenger*; a voyage which in its scope included the circumnavigation of the globe, the traversing the several oceans between the 50th parallel of North latitude and the Antarctic circle, and the exploration throughout, by the medium of the sounding line and dredge, of the contour features, the formation, and the animal life of the great oceanic bed.

The general results of the notable African land journey have already, through our parent society in London, been brought largely under public review; and at our present meeting many details of interest will be placed before you by the intrepid traveller himself. The courage, perseverance and patient attention to the records of this long travel have been dwelt on by our highest geographical authorities, and so far it might appear superfluous to join in praise from this chair; nevertheless, it is to that part of the proceedings of Cameron, the unvarying attention and care he bestowed on instrumental observations, in order to give those proceedings a secure scientific basis, to which I would direct your attention as being of a high order of merit.

With this example before us, remembering the country and climate in which such unremitting labours were carried out, distinction to the future explorer cannot rest on the mere rendering of estimated topographical details, but can alone be fully merited when those details are verified by instrumental observations of an order sufficient to place numerically before geographers the physical features and characteristics of the explored region.

Turning now from the results of the land journey of Cameron to those of the sea voyage of the *Challenger* we are again reminded of the value of repeated and methodically arranged instrumental observations in geographical research. With our present knowledge of the sea-board regions of the globe, little remains, except in Polar areas, for the navigator to do in the field of discovery, or even of exploration, otherwise than in those details rendered necessary by the requirements of trade or special industries. It is to the development of the scientific features of geography that the attention of voyagers requires to be now mainly directed; and in this there is an illimitable field. The great advance in this direction resulting from the two leading events of the past year, to which I have referred, foreshadows geographical research of the future.

Communications of special value from some of those voyagers whose good fortune it was to leave and return to their native land in the ship *Challenger* will doubtless be made to this and other Sections. I trust nevertheless, as one officially interested in the expedition from its inception, and as having in early days been engaged in kindred work, and also as I hope without being considered to have trespassed on the scientific territories of these gentlemen—ground indeed so well earned,—this meeting will view with indulgence my having selected as the leading theme of my address to it, a review of that branch of our science now commonly known as the "Physical Geography of the Sea;" combined with such suggestive matter as has presented itself to me whilst engaged in following up the proceedings of this remarkable voyage.

It has been well observed that "contact with the ocean has unquestionably exercised a beneficial influence on the cultivation of the intellect and formation of the character of many nations, on the multiplication of those bonds which should unite the whole human race, on the first knowledge of the true form of the earth and on the pursuit of astronomy and of all the mathematical and physical sciences." The subject is thus not an ignoble one, and further, it appears to me appropriate, assembled as we are in the commercial metropolis of Scotland, from among whose citizens some of the most valuable scientific investigations bearing on the art of navigation have proceeded.

As a prefatory remark, I would observe that the distinctive appellation "Physical Geography of the Sea" is due to the accomplished geographer Humboldt; it is somewhat indefinite though comprehensive, and implies that branches of science not strictly pertaining to geography, as commonly understood, are invaded; but this intrusion or overlapping of scientific boundaries is inevitable with the expansion of knowledge: and it is difficult to see how the term can be wisely amended, or how the several included branches of physics can be separated from pure geographical science.

We are indebted in our generation to the genius and untiring