THE WORLD WE LIVE IN
The camel can carry a load of at least 1,000 lb. Over the Sahara great caravans, sometimes of 1,200 camels, move from oasis to oasis, taking about two years for the round trip, and transporting goods worth anything from £50,000 to £200,000 (see p. 195).
The World We Live In

An Illustrated Description of all the Lands and Seas of the Globe, their Peoples, Animals, Plants and Products

EDITED BY

GRAEME WILLIAMS, F.R.G.S., F.G.S., F.Z.S.
Editor of "Wonders of Land and Sea"

WITH AN INTRODUCTION BY

LIONEL W. LYDE, M.A., F.R.G.S.
Professor of Economic Geography in University College, London

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LIST OF CONTRIBUTORS

The following Key to the Initials placed at the end of each chapter throughout the work will enable the reader to identify the author in each case—

S. L. B.  S. Leonard Bastin, Contributor to "Wonders of Land and Sea"; Author of "Wonders of Plant Life," "Flowerless Plants," etc.

E. A. B.  Ernest A. Bryant, Contributor to "Wonders of Land and Sea," etc.; Author of "The New Self-Help," etc.

G. A. J. C.  Professor Grenville A. J. Cole, M.R.I.A., F.G.S., Professor of Geology, Royal College of Science for Ireland; Director of the Geological Survey of Ireland; President of the Geological Section of the British Association for 1915; Author of "The Changeful Earth," "Rocks and Their Origins," "The Growth of Europe," etc.

J. D.  John Derry, J.P., formerly Chairman of Sheffield School Management Committee and Member of the University Council; Author of "Across the Derbyshire Moors," etc.

R. J. F.  Robert J. Finch, F.R.G.S.; Senior Geography Master at Hornsey County School; Secretary of the North London Branch of the Geographical Association; joint Author (with Horace Piggott, M.A., Ph.D.) of "World Studies," etc.


A. H.  Arthur Holmes, D.I.C., A.R.C.S., B.Sc., F.G.S.; of the Geology Department, Imperial College of Science, London; Author of "The Age of the Earth," etc.


W. H. K.  W. H. Koebel, Editor-in-Chief of the Encyclopaedia of South America; Author of "Modern Argentina," "Argentina, Past and Present," "Modern Chile," "Uruguay," "South America," "Portugal, its Land and People," etc.

L. W. L.  Professor Lionel W. Lyde, M.A., F.R.G.S., F.R.S.G.S.; Professor of Economic Geography at University College, London; formerly Head master of Bolton Grammar School; Author of "Man in Many Lands," "Man and His Markets," "The Continent of Europe," etc.

L. M. P.  L. M. Parsons, B.Sc., F.G.S., of the Imperial College of Science.
The World We Live In

Introduction

By LIONEL W. LYDE, M.A., F.R.G.S.

Professor of Economic Geography in University College, London

In almost every department of school teaching, recent years have seen the breaking of a new dawn in method; and in the case of Geography the change, though perhaps heralded more quietly than in the case of some other subjects, has been at least equally vital and equally fruitful.

The earth has at length come to be regarded as primarily and essentially the Home of Man, and school Geography is now becoming a study of environment. Its natural divisions are, therefore, not practical, physical, physiographic, but political, historic, economic; and its aim is synthetic, not analytic, the end being a picture, not a dissection.

If this becomes the universal attitude to the subject in our schools, the result on the nation will be incalculable and beyond price; and great will be the reward of those who have played their part in bringing about such a result. For the teaching of Geography as an Outlook—instead of an Inlook—science will be a notable step towards the most democratic of all revolutions.

Of course, the precise place of Geography in school work will vary with the character of the particular school, especially with the average age of the highest class; but if in all our schools attention is concentrated on the human note, even the most elementary survey of the earth will quicken imagination almost beyond belief. For the earth is obviously occupied by many different peoples, in different political units, with different physical and climatic environments, and therefore at different stages of social development and in different typical occupations. This wide relation to human life makes Geography the obvious meeting-place of the natural and the human sciences; and the method employed, if British and appropriate, instead of continuing to be imitated from Germany and inappropriate, will prove equally valuable to the individual, to the school, and to the nation.

For the first work of the Geography teacher in any school is essentially to supply a self-contained course of study suitable to the ages and the character of the particular pupils. This course must be complete by the time the average pupil leaves school, and yet it must fit him to be, as a citizen, an intelligent reader of his daily newspaper, with its home and foreign news. It must also be capable of being a base for further study, in higher classes of the same school or in another school or in a university, for those who
continue their education. In either case it involves a certain body of knowledge and a certain attitude of mind. In the pursuit of that knowledge the teaching will follow all such avenues as are at once necessary for the grown citizen and interesting to the growing boy—who is much more interested in a lion than in a sheep; and the attitude of mind depends on reasonable familiarity with the working of important geographic laws.

These laws, as I am never tired of urging, are not arbitrary; nor is the Geographer’s attitude to them such as it is often misrepresented—e.g. by old-fashioned teachers of history. No Geographer believes that geographic conditions compel man to act or not to act in any particular way in any particular place; but one does believe that man, being perfectly free to act as he likes, normally moves by “the line of least resistance.” For instance, the number of persons who would struggle up the bed of the Kabul torrent in preference to following the Khaibar Pass is unquestionably limited; nor can one believe that primitive man would have neglected to pick the apples which ripen every autumn in millions on the Yablonoi (“Apple Tree”) slopes, or would not have desired to catch or kill some of the innumerable pigs that collect on those slopes every year for the autumn fall of the apples.

Even the worst pupils in an unfortunately situated elementary school stay at school long enough A Great Outlook to have—if rightly taught—some familiarity with the great geographic principles and processes; and, except in rare cases of special deficiency, even such a pupil, when a citizen, would have sufficient familiarity not to be bamboozled by politicians. For Geography, when rightly taught—i.e. taught as a great Outlook—means truer relative values, a wide sympathy with strange peoples and strange ways of doing things, a vivid realisation of political or economic relations—e.g. our obligation to cheap coloured labour or the annihilation of time and space, as evidenced by the ubiquity of the banana. No subject hitherto taught, or as taught, in our schools, has given this statesmanlike power to look all round facts; no power is more jealously grudged to our democracy by politicians of all parties; and yet no power is more valuable to an Imperial Democracy—to the Democracy itself at home and to the Empire which it rules abroad, an Empire of all climates, all conditions of life, all races of man. We often suffer at home, and we sometimes rule badly abroad, because of our imperfect outlook; we lack the bond of real sympathy at home and the insight of real sympathy abroad. And the cause is that we have not learnt in our young days to picture truly and clearly what is beyond our immediate horizon.

But it is the essential business of a rightly taught Geography to teach that very one thing—to picture forms and forces beyond the horizon. Systematic Observation That is precisely why it begins by teaching a child to picture forms within his horizon, and for that purpose takes him out to observe land forms at first hand “in the field,” and then brings him in to model in the classroom what he professes to have observed out-of-doors. Systematic observation of the seen and the known is a psychological necessity for proper understanding of the unseen and the unknown, and you can only test such observation by compelling the observer to reproduce in the concrete his mental picture of the observed object. There is, therefore, no substitute for, nor is there any alternative to, this direct personal observation of the forms out-of-doors; and such observation is largely valueless if it is not associated with the subsequent reproduction of the forms
CHEAP COLOURED LABOUR ON THE CONGO

During the collecting of the rubber, small particles of wood and hard bits of fibre get into it, and to remove these the rubber balls and twists are cut up into slices and put into sacks, which are then beaten by the native workmen with heavy sticks.
Introduction

from the mental pictures. When you have proved a child’s power to do this for forms that are within the horizon, you may trust it to picture truly and clearly forms that are—and for most children will always remain—beyond the horizon.

When the “human note” is dominant in the teaching, as it ought to be, this imagining of forms and forces beyond the horizon is always intimately associated with man. Of course, it is impossible to picture a people apart from some place; and, on the other hand, the power to picture truly foreign peoples in their foreign environment must be as valuable to the business man as to the statesman. In fact, it is precisely this power that makes the statesman; and he does not make the egregiously mistakes that our politicians make, just because he pictures truly and clearly.

Emphasis on the “human note” also brings a child very close up against big Mother Earth in her control of Man; and this is in itself a fine corrective of the narrow, conceited, straw-splitting, bluff-loving, attitude, such as any people must be inclined to adopt who are ruled—whatever party is in power—by lawyers and formulas.

If this general position is sound—and, though the very antithesis of the “statistical” German position, it has been formally accepted by the Association of American Geographers—there are two obvious corollaries. The first is that the amount of attention and preparation devoted to the subject by teachers of it should bear a direct relation to the importance of the subject; and the second is that the place of Geography in the school is not in the Science Laboratory.

As to the former, I am not acquainted with any teacher of Geography who is not intensely anxious to teach the subject well, and who does not devote much time and care to preparation for that precise work; but many of them are handicapped by the inheritance of their own school days. For the younger generation was at school during the first outburst of the “free book” craze: many of them never had a book to call really their own; they were never encouraged, and often forbidden, to mark the books lent to them; the few who did so of their own initiative, left to the inheritors of their books marginal notes and references which were either meaningless or a direct hindrance to further initiative. In a word, they never learnt how to use a book fruitfully. For that reason now, as teachers, they often do not realise the imperative need for a small library of their own, and they economise in the particular line which is of all the richest in returns on a small investment. They inherit, too, the aversion of those who, with a large stock in trade, are unwilling to “scrap” old machinery in order to introduce better.

It is the same mechanical, Germanic influence that has encouraged both the over-emphasis of survey and other purely “Inlook” work in our school Geography, and the tendency to relegate Geography to the science laboratory. That is essentially the place for “Inlook” work; and there are several other sciences which are both suitable for school use and admirably fitted to train the “Inlook” faculty. There is no science except Geography which is both suitable for school and fitted to train the “Outlook” faculty—helping to save the individual from social pettiness and political parochialism, and to save the nation from citizens with no power of taking a wide outlook or of putting themselves in the place of others.

To waste that one Outlook Science, by limiting it to the work—the useful, necessary, admirable work—of pestle and mortar, would be a piece of criminal stupidity for which the nation would have to pay.

W. L.
1. How Geography affects History

The Importance of Geography—British Monarchs' Studies of Geography—Early Expeditions to Africa—Neolithic Man—Likes and Dislikes to Locality shown by the Human Races

How history and politics can be severed from a close attention to geography passes the comprehension of the ordinarily intelligent man or woman. But apparently it has for long escaped the attention of the official mind in our haphazard native land and haphazard Empire that has grown up around it.

We are most of us familiar with the stale anecdote of Lord Palmerston, which apart from its staleness would certainly not raise a laugh at the present day, but be taken quite seriously: how, when he nonchalantly assumed the office of Secretary of State for the Colonies, he called on some permanent official to unroll the wall-maps of that day “so that I may see where all these places are.”

The writer of these lines can recall an interesting visit to the late Mr. Joseph Chamberlain in the spring of 1889. The creation of a great Chartered Company to take over from savagery and to administer a vast stretch of country in South-central Africa had been mooted, and Mr. Chamberlain wished to know “where all these places were.” So I accepted the invitation to explain, and called on him at his London residence. He referred, with eye-glass in eye, to a great wall-map, and also got out all his atlases; but, alas! the maps of South and Central Africa were virtually blanks at a short distance from the coastline, so that the vital geography of these regions, which were threatening quarrelsome disputes between Great Britain and other Powers, as well as with native States, had to be rudely inserted with pen and pencil. Mr. Chamberlain perhaps realised more keenly than before the close connection between geography and politics, and I understood him to say he would never again be left in the lurch: his library should possess the latest maps that the mapmakers of Edinburgh, London and Leipzig could supply.

Fortunately, this was then as now a very cheap luxury and one within the
TWO MILES ABOVE SEA LEVEL ON THE SUMMIT OF FUJI YAMA

This, "the peerless mount" of Japanese writers, and the loftiest summit of Japan, is an extinct volcano of comparatively recent elevation which has done much to inspire Japanese art and poetry.
Early Discovery

range of any well-to-do artisan. Yet the lesson learnt by Mr. Chamberlain did not at once penetrate all the official world, for we find in correspondence between the Royal Geographical Society and the Foreign Office some twenty years later a protest from the Society against the non-inclusion of geography amongst the subjects in which candidates for the Foreign Office and Foreign services were to be examined.

In the curriculum of the examination of nearly all public servants abroad, down to quite recently, geography was either not included, or the marks allotted to it were so poor that the candidate preferred to take up Latin, Greek or Algebra instead. And yet geography should have come first on the list, even if some of these more abstruse subjects were nowhere.

I scarcely know any argument so potent for the presumption that there is a presiding extra-mundane Fate that rules this world and its development, and that the British nation has long enjoyed the special favour of this Providence, than the contrast between the ignorance of our statesmen in the past on vital questions of geography, and nevertheless, the growth, the prosperity and the enviable scope of the British Empire. I suppose the real explanation of this anomaly is that our ignorance of geography has often been assumed as a silly manner of self-depreciation, and that most of us, gentle and simple, have had a pretty shrewd appreciation of the world—of geography, in fact—ever since we were influenced by the Romans, the Jutes, the Angles, the Saxons, the Norsemen, the crusading Normans, and the industrious Flemings.

Ever and again in the fifteenth, sixteenth, seventeenth, eighteenth, and nineteenth centuries, we have had a monarch or a statesman of keen intelligence and prospective imagination, who, whether or no the or she may have learnt the geography of the day or given much attention to its maps, was not too exalted in his or her own imagination to listen to quite humble mariners, wandering gentlemen, poor students, and intelligent foreign refugees. Thus Henry IV., not long after he usurped the throne of England, received envoys from Morocco and took a very keen interest in the possibility of developing a British trade with North Africa.

Even earlier than this, Plantagenet monarchs had interested themselves in opening up a British commerce with the Levant and had listened, no doubt, to Genoese pilots and merchants who had sought to enlist English enterprise and wealth on the Genoese side in the long rivalry with Venice. Edward IV. and the much misjudged Richard III. had concerned themselves with relations of amity and commerce with Portugal, which might lead to British over-sea adventure.

Henry VII., though not an easy man to get money out of, or even to approach, nevertheless listened to Sebastian Cabot and fostered the British discovery of Newfoundland and Nova Scotia, the first British claims to a share in the New World. His son, Henry VIII., dispatched ships in a similar direction and certainly had the word "America" uttered at his Court in masques and poems, when it was scarcely known elsewhere outside Lorraine and North Italy.

Queen Elizabeth probably knew more political geography than any sovereign of her day, and gave an immense impetus to geographical discovery by her encouragement of Drake and similar wonder workers and super-men of that time. Prince Henry, the promising son of the nasty-minded James I., absorbed all the geography he could get hold of and encouraged the formation of chartered companies to found colonies in the New World. Oliver Cromwell took a profound
interest in geography, and however different in other respects might be his immediate successors as rulers of England—Charles II. and James II.—they likewise made a considerable study of geography and laid the foundations of much of our colonial empire in America, West Africa and India.

Geography was the romance of Anne's reign, and the opening years of George I. There was still more than half the world unmapped, and the brain of a Swift could place anywhere in the Pacific Ocean or between Africa and Australia the allegorical countries of his imagination. His island of Laputa was actually based on much of the information then current about Japan. Daniel Defoe makes his "Robinson Crusoe" a vehicle for fascinating geographical information, a good deal of it perfectly true and derived from keen observers amongst pioneers such as Dampier.

Robinson Crusoe's adventures, you remember, wind up with a very matter-of-fact journey to North-east Asia and the overland route through Siberia to Russia. And it all reads with a singularly modern flavour after the sixteenth-century atmosphere of his Carib Island (probably intended more or less for Tobago).

In the late middle of the eighteenth century there arose a statesman, immoral and venal after the fashion of his day, but with a great mind—Lord Halifax—who assisted and encouraged James Bruce to make a scientific exploration of North Africa, and to hunt for the Nile fountains of Greek and Roman geographers. Similarly, Lord Camden in 1804 dispatched Mungo Park to explore the whole course of the Niger; Lord Sandwich, Lord Dartmouth and their brother statesmen of 1771–6 sent out Captain James Cook and his great successor, Captain Vancouver, to lay bare all the secrets of the Pacific and of the Southern Ocean, to survey the narrow straits between Arctic Asia and Arctic America, and to determine once and for all the coast geography of the Australian Continent and of New Guinea.

No sooner were the Napoleonic wars over and done with than the British Cabinet of that day determined to continue the task left unfinished by the great Mungo Park, and to find the real outlet of the Niger. Consequently, Captain Tuckey's expedition was sent to the Congo, as the Congo was then thought to be the most probable mouth of the Niger. The whole nineteenth century was, in fact, one glorious blaze of geographical discovery instigated or supported, or at any rate not discouraged, by British statesmen and politicians.

Yet, side by side with all this, British interests and the British Empire from time to time suffered grievously from a lack of sound geographical knowledge on
A SINGHALESE FAMILY IN CEYLON

Unlike the Fuegians opposite, whose energy and strong build enable them to endure the rigours of their inhospitable climate and to run down game for their support, these forest dwellers are of poor physique and languid temperament. A warm climate and abundance of coconuts for food render sterner qualities unnecessary.
How Geography affects History

the part of the major and minor officials, more especially those accustomed to direct the affairs of the Empire from a comfortable arm-chair in a Whitehall office. In the settlement which followed the Napoleonic wars, for example, we restored to various colonial Powers small islands, or vague rights over fisheries, not so much from a spirit of good-will or policy, as because the officials who composed the treaties were too ignorant of geography to realise what they were giving away.

We gave back the islands of St. Pierre and Miquelon off the coast of Newfoundland to France, and thereby had to bear for nearly a hundred years afterwards vexatious disputes with France about Canadian and Newfoundland Fisheries which several times brought us to the verge of war. Similarly, we restored a portion of Guiana to France, and another large portion to Holland. Yet neither of these Powers had specially begged for a scarce appreciated boon. Had we known more about Guiana geography we should have done nothing of the kind, even though we had made equivalent concessions elsewhere, as, for example, in West Africa. We should have retained in our hands (what we once held for a short time) the whole of the Guianas; and thereby have administered one of the most valuable portions of South America.

Again and again from lack of geographical appreciation we have been within an ace of losing the Falkland Islands, despite their immense strategic importance. Lack of interest in, or knowledge of, geography nearly lost us the Lower Niger and the great empire of Northern Nigeria, which were only saved to the British Empire by the “vexatious obstinacy” of Sir George Goldie. Lack of interest in geography in high quarters made much of Livingstone’s life-work fruitless at the time; and there again it was not altogether official foresight (though the late Lord Salisbury had much to do with the final decision), but the “cussed” tenacity of missionaries which secured for Great Britain her enormous empire over what is now called Rhodesia, British Central Africa, British East Africa and Uganda.

The late Lord Salisbury, to whom I have referred, was a statesman who at the same time was a great geographer and consulter of maps, “large maps as well as small maps.” Though he had never, so far as I am aware, visited more of Africa than perhaps Cape Colony and Natal, his knowledge of African geography was surprising, and to him must certainly be given the chief credit in endowing us with our magnificent African Empire of to-day.

In the minds of the first real men of science—the Greeks, between about 400 B.C. and A.D. 150—and those of the Latin writers who pursued the same studies, Geography and History were treated as one science. These Hellenes and Italians of two thousand years or more ago had already realised how closely the two are interwoven. Herodotos is called the father of history in a time-worn cliche, and he was also the first tolerably scientific writer on geography.

Geography has made history, and history in its turn has made geography.

The great plains of Russia with their extraordinarily fertile soil had a profound bearing on the course of world development. So long as Man remained the predatory hunter, almost invariably nomadic, there was little history mixed up with geography. He wandered where the food was easiest procured. If the climate changed, or other circumstances made edible wild animals scarce, wild berries, grains and roots less abundant, he shifted from the caves or wigwams of his ancestors. Thus he sampled all parts of the habitable land surface of the globe which he could possibly reach, first by continuous land connections, and
Rise of Great Civilisations

later by means of rude rafts and dug-out canoes. He over-ran in this way all Europe to the Arctic Ocean, and all Africa, Asia, Australasia, and America. But in East Russia, or in adjoining portions of West Asia on the other side of the Ural Mountains, some great section of the proto-Caucasian peoples called a halt. They not only found the climate to their liking and to the improvement of their physique, but the right kind of wild animals were abundant, owing to suitable herbage; and the soil was obviously productive. The rich crops of wild grains were so easily fostered that agriculture began. The foals of the wild horse, the calves of the wild oxen, the kids of the wild goats and sheep, the fawns of the reindeer, the puppies of the wild dogs, the piglings of the wild swine, were so easily tamed and reared that the keeping of domestic animals on a large scale here began.

With more settled residence, greater comfort, greater security in food supplies, Man entered the Neolithic age. Henceforth he began to make carefully chipped and polished stone weapons and implements; and his constant search for better and better stone material inducted him into the use of malleable metals. Similar processes, either contemporaneous, subsidiary, or subsequent, were going on in other favourably situated regions; in the great—and at that time fertile—plains of Mesopotamia, between the Armenian and Persia moun-
tains, the Syrian Desert, and the head of the Persian Gulf; in the Valley of the Nile and the Nile Delta; in the centre and south of France; in Southern or Eastern Spain; in Algeria and Tunis; in the Rhine Valley; and above all in the beautiful island of Crete, other islands of the Ægean and the southern coasts of Asia Minor. Later there began to arise great civilisations in the Valley of the Ganges, in North-central or North-east India, in the vast and fertile plains of Eastern China, in the island of Sardinia, in South Britain, in Central Italy, in Sicily, and Greece; and, in the New World, on the cool yet sunny plateaus of Mexico, Colombia, Peru and Bolivia.

The Forest—really dense forest—was as a rule avoided by Neolithic Man, and Man in the early metal ages. It sheltered dangerous wild beasts, venomous snakes and scorpions. It exhaled mysterious
How Geography affects History

diseases—mostly imparted through germ-conveying insects, ticks or leeches. It depressed the spirits with its gloom and darkness. As the result of storms, or the suddenness consequent on great rainfall, huge trees would come toppling over without warning. Thorns tore the naked skin or pierced the feet of the wanderer. There were weird cries of tree-haunting beasts, birds, lizards and frogs, which had much to do in fostering the early speculations about religion—speculations nearly always of an alarming kind.

In short, though Man had sprung from the forest in the remotest past, he had only become Man by leaving the forest for the open country; and his return to it, his affection for it, has been in most cases quite a recent element in his mental composition. The forest, therefore, came to shelter the unsuccessful and utterly savage peoples, and became in Africa, in Malaysia, India, New Guinea, the last haunt of the Pygmies, Negritos, and the Veddahs.

In Europe, no doubt, the forests were the final refuge of the ogres of fact, who in time became the ogres of fiction. These may have been the survivors of Neanderthal Man or of the far more horrible cannibal Negroes and Australoids, who probably lingered on in Europe and Asia long after the open country and even the mountains were populated by real White men, by intelligent Mongols, or by highly civilised Negroids.

Similarly, in the New World the dense forests of conifers, evergreen oaks, maples, birches, alders, walnuts, hickories, magnolias, persimmons, and liquidambars were rather shunned than inhabited by the Amerindian population. The special developments and civilisations of these people occurred on the great prairies, along the coast regions of the Atlantic (where the forest could be better subdued), in Central Canada, in the arid regions of Colorado, New Mexico, and Lower California.

The West India Islands were not densely populated in their interiors, but along their beautiful sea coasts. In Central and South America the forests either had no human population at all, or it was of a savage, outcast type, like many of the existing Amerindian tribes of forested Brazil at the present day.

In our own land there would have been little civilisation developed by the Iberians, the Keltiberians and the Kelts, had it not been for the open down-lands and heaths. These, at any rate, served for the nucleus of flourishing colonies; and the stone, bronze, or soft iron axes of man began to fell the forests and widen the area of cultivable, habitable land.

The whole history of Ireland and Britain during the last 2,500 years has been one of gradual deforestation, till at last the absence of woods and of useful timber is beginning to occupy our attention seriously, with a view to a reasonable degree of re-afforestation.

In many parts of temperate and subtropical Asia and Europe, man’s attacks on the forest have changed the local geography. He and his domestic animals, especially the goat, have reduced densely forested regions like the island of Cyprus, much of Greece, of Sicily, and Sardinia, of the Mediterranean basin generally, of North Africa, of West Asia, to a condition of aridity and sterility.

Following on the disforesting has come denudation. There has been nothing to prevent the torrential rains of winter or early summer from tearing away the soil from the rock. The rivers have become torrents of destructive force; only in course of time to become dry river-beds, at any rate during much of the year. The absence of trees has brought about a gradual diminution in rainfall by altering the conditions of the atmosphere just over the land; or the rainfall has not been properly diffused.

On the other hand, Man’s natural
MESOPOTAMIA, THE LAND OF A GREAT PAST AND A MIGHTY FUTURE

Until its ancient irrigation system was destroyed by the Tartars, Mesopotamia was one of the most fertile countries of the world. This diagram gives a bird's-eye view of Sir Wm. Wilcock's vast scheme for the restoration of the irrigation system, which will cost £15,000,000. The first section, the Hindia barrage, was completed by Sir John Jackson, Ltd. in December, 1913

Drawn by G. F. Morrell
dislike to the marsh, his constant interferences with Nature in restricting rivers to a fixed course, in deepening their beds, in cutting canals, in irrigation, has again brought about, first by slow degrees, and then by far-reaching effects, a change in local geography. What were once shallow lakes are now fertile, densely populated valleys; the sea has been driven out of much of Holland, and instead of a nearly profitless ocean, producing at most a few fish for man’s consumption, we have settled on soil reclaimed from the North Sea several millions of the most productive, highly civilised and amiable of the world’s races.

Mountains, like forests—though not to the same extent—have served for a time as the last refuge of inferior races. But they have also given an opportunity of recovery to races temporarily worsted in the struggle with Fate, or with stronger and perhaps more brutal types. Thus sheltered they have acquired special qualities, a special perfection in certain qualities that have not only enabled them in their turn to assume the rôle of conqueror, but have at any rate fostered their existence till they could present the world with a local type of particular usefulness.

Mountains and plateaus have in the long run greatly benefited the advance of humanity, for the reason that they have gradually created by their local conditions human races of greater hardihood, courage, abstemiousness, thrift, and physical endurance than those leading the easier life in the plains below. Thus has the vigour of humanity been renewed again and again.

Though the Aryans were evolved probably in a region of great plains and slow-moving rivers, such as Eastern Russia or Western Asia, they, by their long training in a climate of hard winters, were almost equivalent in vigour to a mountain race. In their southward and westward migrations, moreover, they took readily to the mountains; so that when they descended (in the break-up of the Roman Empire from about A.D. 300) from the Alps, Carpathians and Balkans into the sunny plains of Italy, Provence and Byzantium, they really came as mountain people.

The Lombards no doubt made themselves quite odious to the civilisation of the day in the plains of the Po and other parts of Northern Italy below the Alps. But they invigorated the Italian population to a quite remarkable degree; as had done, though with less effect, their Gothic predecessors. After the Lombards had had their day the Normans similarly gave vigour to Southern Italy.

Towns (and the civilisation which grows up in a town and perhaps becomes world wide) are likewise the creatures of geographical conditions. Whether they could give rhyme or reason for it, some of the great conquerors of the past were instinctive geographers and appreciated this fact. Alexander, when he founded Alexandria on the site of some Perso-Egyptian fishing village, took in at a glance its possibilities as a harbour for world commerce; and Alexandria became then, and remained almost down to the beginning of the nineteenth century, the virtual capital of Egypt.

Alexandria, in fact, re-made Egypt. Yet, however it might be styled—Memphis, Babylon, Heliopolis, Fostat, Masr, Al Askar, Al-Katai, or Al-Kahira—there was always for thousands of years a town somewhere near the site of modern Cairo. There had to be such at the opening of the “fan” of the Nile delta: such an obvious centre for commerce and for rule.

Byzantium — Constantinople — was another obvious site for a great capital. But apparently it attracted the attention of no far-seeing statesman until Constantine the Great recognised Christianity and founded the Eastern Empire of
The Sites of Cities

Rome. Here was maintained much of Roman civilisation during the Dark Ages, when Constantinople was the Paris, and Milan the London, of the mediaeval world.

London itself, Marseilles, Hamburg, New York, Rio de Janeiro, Inevitable Capitals Boston, Valparaiso, Buenos Aires, Lisbon, Cadiz, Tunis, Cape Town, San Francisco, Vancouver, Sydney, Bombay, Baghdad, Petrograd, Athens, Smyrna, Salonika, Canton, and Tokio, are amongst the world's inevitable capitals. Great cities, great agglomerations of humanity had to be in those places; because of a favourable harbour, an important river (easily approached and entered with a long, navigable course penetrating far into the interior), good sanitary conditions, tolerable climate, and the certainty of being an outlet for great areas of production.

But there are other great towns where local conditions are either unfavourable or adverse, but where the obstinacy of Man has completely conquered Nature and made these cities for ever famous, has twisted geography, so to speak, to feed them and maintain them.

Such is Venice, for example. What supramundane intelligence, understanding all earth conditions and looking down with a magnifying glass at Mediterranean Europe, would have lit upon the site of Venice as suited for a great centre of commerce, art, and sea-power?

In the opening centuries of the Christian era it was a shallow region of brackish water, sandy or muddy islands, a kind of extension of the estuary of the River Po. To these islands, however, during the great troubles which followed the dissolution of the Roman Empire of the West, fled the Romanised Celts of North-east Italy. On these islands and islets, some of them scarcely more than a foot or two above

A STREET SCENE IN VENICE

Photo: Donald McRitch
VARIED TYPES OF HUMANITY ADAPTED BY NATURE

Natives of: 1, 2, Mascarene Islands; 3, 4, Guinea; 5, Tunis; 6, 7, Society Islands; 8, Marquesas Islands; 9, 10, Leeward Islands; 11, Ivory Coast; 12, Upper Guinea (Kru-Negroes); 13, French Congo; 14, 15, Sudan; 16, Dahomey; 17, 18, Guinea; 19—21, Windward Islands; 22, Senegal; 23, Sudan; 24, Sahara (Touareg Warrior); 25—28 (Oudoucha Warriors); 29, Gabun; 30, 31, Melanesia; 32, Ogowe River, W. Africa;
TO SUIT DIFFERENT SPECIAL ENVIRONMENTS

33—36. French Congo; 37—39, Senegal; 40—43, Guinea; 44—46, Central Africa (Peulhs); 47, 48, Guiana; 49, 50, Sudan; 51, Algeria; 52—54, Madagascar; 55—57, New Hebrides; 58 (Arab); 59, 60, Madagascar; 61 (Arab Woman); 62—64, Madagascar; 65—67, Tunis (Jews); 68—70, Tunis; 71—74, India; 75, Indo-China; 76, India; 77—83, Farther India; 84—86, Polynesia; 87, 88, W. Africa; 89—94, Farther India; 95—97, China
How Geography affects History

high-water mark of the nearly tideless Mediterranean, the refugees with infinite trouble established their pile dwellings, and in course of time, with a foundation of enormous tree trunks and of imported rubble, they reared the exquisite beauty of Venice. Moreover, they established a precedent, and Man subsequently sought here and there to find other Venices on other congeries of low islands, but seldom with success.

Madrid, in the very centre of Spain, was a less happy example of human obstinacy. Its site was chosen by Philip II. as the future capital of all Spain, mainly because it was very nearly in the middle of the Spanish peninsula. But it has a very poor water-supply on a quite unnavigable river, and a climate of extremes—intensely hot in the summer, bitterly cold in the winter—disagreeably warm on the sunny side of the street, dangerously cold on the shady side. Yet somehow or other Madrid has lived on through the centuries and will probably never be dispossessed as the capital of a great kingdom; slowly Man is meeting the local disadvantages and overcoming them.

The same may be said about Calcutta, which became the capital of British India and is barely dispossessed as such even now. It began merely as the very unhealthy site of an English trading station. Madras is perfectly insalubrious as a capital for Southern India, but there again Man is gradually supplementing Nature’s resources or suppressing disadvantages. There is no particular reason geographically why Paris should be the lovely city that it is—nearly, if not quite, the most beautiful city in the world—or the political capital of France, but it has become such, and will remain no doubt the chief city in France for centuries and centuries to come.

Still less is there any reason why Berlin should be the capital of modern Germany, except for the fact that it was the headquarters of the Brandenburgers. Hamburg, Leipzig, Stuttgart, Frankfurt-on-the-Main, Cologne, or Nurnberg—or even Vienna—are far more suited in convenience of approach, in navigable waterways, in delightful amenity of surroundings or of climate, to be the capital of an Imperial Germany.

Similarly, there is no geographical reason why Moscow should have been for long the capital of the Russian Empire. Still less reason (geographically) why Rome should have attained to such superlative greatness, or why Washington should be tolerated as the administrative centre of the United States, or Sofia be the capital of an intelligent Bulgaria. But by dint of centuries or millenniums of stirring history and of great achievements, by the beauty due to man’s hand and brain, though not to natural surroundings, all of these places will remain famous capitals and centres of human activity.

Still, if any empire-builder should chance to glance at these pages, my counsel to him would be, if he be seeking to found a city which shall be a worthy rival to those that have made past history, he should plant it on a broad and navigable river, on ground that is neither too rocky and mountainous, nor marshy, not near enough to the seacoast for bombardment by long-range cannon, and not too far inland for seaborne commerce, not in a region with too perpetually warm and enervating climate, nor in one which is disagreeably cold. It must not be too dry, and it must not be too damp; it must have lots of sunshine, and yet refreshing and cleansing showers.

In short: let him, let every working and voting citizen and citizeness study geography.

H. H. J.
2. The Making of the Earth

Geography and Geology—Shape and Weight of the Earth—Radio-activity and Geology—Radium and Thorium—Age of the Earth—The Solar System—Origin of the Earth—The Planetesimal Hypothesis

GEOGRAPHY deals primarily with the surface relief of the earth, and from this general basis it considers, on the one hand, the processes which gradually modify the geographical conditions of the earth’s surface, and, on the other hand, the effects of those conditions on the earth’s inhabitants, with reference more particularly to the activities of Man. It therefore follows that geography is deeply rooted in the more fundamental science of geology, the object of which is to trace in the records of the rocks the successive geographies of past ages.

Working back through the dim periods of the earth’s long history, one arrives at last at the beginning of geological time, and the rocks fail to help us further in unravelling the secrets of that far distant past. Yet it is becoming more and more evident that to understand the face of the earth as we see it to-day we must first of all understand the fundamental processes which were involved in the making of the earth and in its subsequent evolution.

In this chapter we shall try to penetrate the veil of uncertainty which lies beyond the earliest periods revealed by geology. The attempt to solve the problem of the origin of our planet is at once the most ambitious and difficult task with which the geologist is faced. Yet it is not altogether hopeless. The sister
The Making of the Earth

sciences lend their aid. Astronomy brings to us a knowledge of other worlds. The spectroscope explores the infinite stage of the heavens and reveals to us every phase in the life history of a star. Another far-reaching instrument, the seismometer, records the shocks of earthquakes, some of which pass through the deep interior of the earth and come up again to the surface with a record, obscure but valuable, of the conditions which they encountered in the depths.

From the furthest recesses of the universe, from the mechanism of the solar system, from the interior of the earth, and from the heart of the chemical atom the information is culled which leads our imagination to a correct conception of the birth of our planet.

Let us consider first of all the evidence which the earth herself can give us. Before building up a broad synthetic theory of the earth's pre-historical or pre-geological stages we must analyse the more critical aspects of the phenomena which demand explanation and with which our completed theory must be in harmony.

The shape of the earth is not quite spherical, but approximates to an oblate spheroid. The polar diameter is 7,899 miles, but the equatorial diameter is 7,925½ miles, implying a polar flattening which amounts to 26½ miles. However, this is only a rough description of the shape, for the distribution of land and sea interferes with the ideal surface of the earth-spheroid, and moreover, the Equator is an ellipse rather than a circle.

The shape of a flattened pear or peg-top perhaps gives a better idea than does that of the time-honoured orange, for the south polar regions are occupied by a lofty continent—corresponding to the stalk of the pear—whereas the arctic region is a sunken area occupied by a great ice-mantled ocean.* To say that the earth is a geoid tells us nothing more than that it is earth-shaped.

The weight of the earth, or what amounts to the same thing, its average density compared with that of water, is the first factor leading to a knowledge of the interior. The earth was first successfully weighed by Mas-kelyne, then Astronomer Royal, in 1774 and the two succeeding years. He measured the attraction which the mountain of Schiehallion, in Perthshire, exerted on a plumb line suspended at its foot.

Had there been no mountain the plumb line would have hung in an exactly vertical position. As it was the mountain pulled the plumb line towards itself, and the deflection, which was accurately measured, served to determine the weight of the earth compared with Schiehallion's.

A careful survey of the mountain was made, its average density was found to be just over 2½, and since the actual deflection was only 1½ of what it would have been had earth and mountain been equally dense, the average density of the earth was found to be nearly 5.

Another earth-weighing experiment with Arthur's Seat as the comparing weight, gave a result of 5½. More delicate experiments conducted in the

* The stalk and flat ends of the hypothetical pear are sometimes said to correspond with Central Africa and the Pacific respectively.
The Earth’s Density

laboratory, in which the attraction of smaller weights is compared with that of the earth, have led to more accurate results, and we now know that the earth’s average density is 5.53.

than those which build up the continents. It is obvious, therefore, that the earth’s interior is heavier than its outer crust.

It has often been suggested that the downward increase of density is due to

![THE TETRAHEDRAL THEORY OF THE EARTH](image)

The land masses form a broken ring around the North Pole, from which three continental ridges, two of which are shown here, run to the south, where they are separated from the South Polar continent by the Southern Ocean (see pp. 44-46)

From our knowledge of the rocks which make up the continental masses we know that the outer shell of the earth has an average density of 2.8. Rocks from oceanic islands average 3, suggesting what is implied by other evidence, that the rocks under the oceans are heavier the high pressures which must obtain at great depths, but no evidence has ever been brought forward in support of this contention. More probable is the alternative view that the nature of the rocks, their mineral and chemical composition, varies with depth in such a way
The Making of the Earth

that the heaviest are found in the central core and that around it are successive zones of rocks which become gradually lighter as the surface is approached.

In favour of this view, as far as the immediate crust is concerned, geological evidence is strong. All the continents are built up on a platform which is essentially made of granites (density 2.98). Coming through these rocks from below are widespread intrusions of basalt (density 2.86). Everywhere—in the mountains and plains, and from the ocean floor—their chemical composition is strikingly uniform. The conclusion drawn is that below the granite shell of the continents, a world-wide zone of rocks of basaltic composition would be found, if we could penetrate to a sufficient depth.

Unfortunately we cannot directly delve into the earth's interior for more than a mile or so. But while the far interior is not amenable to direct exploration, the earth itself performs giant experiments for us, whenever a great earthquake occurs. (See pp. 48-49.)

Earthquakes set up three kinds of waves, one of which passes around the surface rocks, while the other two pass right through the earth and can be recognised and recorded at distant stations by seismometers. In the first place, one of these waves travels more slowly than the other and is of a type which can travel only through rigid matter. It is certain, therefore, that whatever may be the effects of high pressure and high temperature on the rocks at great depths, they act as though they were solid, and we have no term to describe their condition in any better way.

The same conclusion is drawn from other sources of inquiry. Everybody is familiar with the ebb and flow of the tides. The same forces, set up by the moon and to a less extent by the sun, which are for ever pulling at the mobile waters of the ocean, are also straining the apparently immovable rocks. Tides have recently been detected in the solid earth, and London with all its huge buildings is known to be imperceptibly rising and falling through a distance of half a yard twice a day.

These strange tides which sweep round the earth are of just the height that the moon's attraction could produce if our planet were a globe of solid steel. The fortnightly tides of the ocean tell the same story, and still more confirmatory evidence comes from the fact that the earth does not spin on its axis quite steadily, but nods a little, like a top not quite fast asleep. The nodding is just that of an earth of solid steel. The surface rocks, however, are very much weaker than this, and hence it is clear that the interior must be even stronger than steel. Combining this conclusion with the earth's magnetic properties we are prepared for the view that the central core is largely composed of iron.

Earthquake waves, however, tell us more than this. As they make their way downwards their velocity changes at certain depths, where they encounter what are called "surfaces of discontinuity." Dr. Oldham discovered that the waves travel faster and faster down to a depth of about 2,000 miles under the continents, but of only 1,000 miles under the oceans. Below these levels the waves slow down, indicating a change in the materials through which they pass. More detailed work at Gottingen University has shown that such changes occur not only at 1,000 miles, but also at depths of 750 and 1,500 miles.

It is thought that below the 1,000 mile level the core within is made up chiefly of iron (density 7.8), whereas the other zone is chiefly of stony material (density 3.4), the surface rocks with which we are familiar becoming common only in the outer 20 or 30 miles. This remarkable
THE SOUTH POLE NOT A FIXED POINT

How the position of the Pole shifts in relation to the Heavens and how the rotation point shifts in the Earth itself. This diagram, which for the sake of clearness is drawn on an exaggerated scale, gives a clear idea of this remarkable oscillation.
result is in complete harmony with the earth's density, strength, and magnetic properties; and curiously enough is supported by a totally different kind of evidence.

Meteorites, those amazing bodies which from time to time fall from the sky, provide a valuable clue to the nature of the earth's interior. They allow us to read at our leisure many of the secrets which are otherwise locked up in the impenetrable depths beneath our feet. Their densities, and their structures, forebode suggest that they are the broken up fragments of some other world.

The heaviest varieties (density 7-8) in which iron largely predominates, bear all the marks of high pressure and temperature. The lighter varieties (density 3-4) are made up of stony minerals identical with those of the earth's ultra-basic rocks, and are characterised by structures corresponding to lower temperatures and pressures. Between these two chief types very few intermediate examples are known.

The conclusion that the iron meteorites formed the core of the parent body and that the stony ones lay in a zone around it is inevitable, so consistent is the detailed evidence on which it is founded. The explosive disruption of some other world has revealed to us its internal structure, and from it increased support is given to the strikingly similar conception—indeed, independently arrived at—of our own planet.

Yet another line of evidence remains to be considered, and this, which is final and conclusive, lies in the domain of radio-activity. The science of radio-activity is still in its infancy, being but ten years old, but already it has been rich in results of the utmost value, fundamental in their importance and revolutionary in their significance.

There are two families of radio-active elements, the parents of which are respectively uranium and thorium. Each of these slowly disintegrates, giving out energy in the form of rays which ultimately appears as heat, and passing into other radio-active elements with lower atomic weights. At various stages, eight in the case of uranium and six in that of thorium, rays are explosively emitted which consist of atoms of helium. The most familiar member of the uranium family is radium, and it is therefore convenient to use radium as an alternative name for the whole series. Ultimately, the disintegrating atoms spend their excess of energy and settle down in a permanently stable form, which in the uranium-radium family is lead.

The most essential features of radio-activity are, first, that it is an atomic transformation, and, secondly, that it proceeds at a regular rate which cannot be varied in the slightest degree by any known means. Temperatures up to 2,500° C. and pressures of 160 tons to the square inch leave the rate of disintegration absolutely unaffected.

Now such conditions fairly represent the conditions within the earth up to a depth of about 50 miles, and it is therefore certain that within that depth radio-activity proceeds in exactly the same way as when it is under observation in our laboratories.

Geologically, the importance of the radio-elements lies in their spontaneous generation of heat. The actual amount has been very carefully measured and we know that :

(a) 1 gram of Radium (implying the whole uranium family) evolves $6.3 \times 10^{-2}$ calories per second;

and that :

(b) 1 gram of Thorium (implying the whole thorium family) evolves $7.5 \times 10^{-2}$ calories per second.

The next step is to find how much of these elements is present in the rocks of the earth's crust. This work was
Radio-active Elements

begun in 1906 by Professor Strutt and has been continued since by Professor Joly, by the present writer, and to a less extent by other workers.

The table on this page gives the quantity of radium and thorium in each of the common types of rocks and meteorites. It will be noticed at once that—

(a) Igneous rocks, which are rocks formed in the earth's crust by the consolidation of molten rock material brought upwards from below (e.g. granite and basalt), contain more of the radio-elements than sedimentary rocks, which are rocks formed on the earth's surface from the broken up fragments or dissolved materials of pre-existing rocks (e.g. sandstones and limestones).

(b) Among the igneous rocks, those rich in silica and alkalis (the lighter rocks) contain more radium than those poor in silica and alkalis (the heavier rocks).

(c) Among the igneous rocks, those which have risen up to the surface and have there been expelled in the form of ashes or lava (volcanic rocks) are more radio-active than those which have not succeeded in reaching the surface, but have crystallised from a molten condition at some depth below the surface (plutonic rocks).

(d) Among meteorites the stony varieties contain more radium than the metallic ones, and just as in meteorites, terrestrial iron is also free from radium.

Now, small and unwieldy as the actual quantities of these strange elements may be, yet they give out an altogether embarrassing quantity of heat. The average composition of the earth's crust is well represented by an equal mixture of the acid and basic igneous rock types. Thus we know that each gram of the average material of the earth's crust contains $1.7 \times 10^{-12}$ grams of radium which can generate $10 \times 10^{-14}$ calories of heat per second; and $1.6 \times 10^{-5}$ grams of thorium which can generate $12 \times 10^{-14}$ calories per second. Hence every gram of average rock develops $22 \times 10^{-14}$ calories during every second on account of its radio-activity.

Now, as a balance to this, the earth is constantly losing heat by conduction of heat to the surface from the more highly heated depths below, and radiation of that heat into space.

We can calculate the total loss from a knowledge of the area of the earth's surface, the average conductivity of rock for heat and the rate at which the temperature falls from the interior of the earth to the surface, a factor called the temperature gradient. Deep mines and borings give us some idea of this factor, and it is found that for every 100 metres below the surface the temperature is

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### Table to Show the Distribution of the Radio-active Elements in Rocks and Meteorites

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<thead>
<tr>
<th>Type of Material</th>
<th>Radium*</th>
<th>Thorium*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(in millimillions of a gram per gram of material)</td>
<td></td>
</tr>
<tr>
<td>1. IGNEOUS ROCKS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocks rich in Silica</td>
<td>0.0000031</td>
<td>29</td>
</tr>
<tr>
<td>(acid)</td>
<td>0.0000027</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>0.0000021</td>
<td>17</td>
</tr>
<tr>
<td>Rocks</td>
<td>0.0000019</td>
<td></td>
</tr>
<tr>
<td>Rocks poor in Silica</td>
<td>0.0000011</td>
<td>5</td>
</tr>
<tr>
<td>Silica (basic)</td>
<td>0.0000009</td>
<td></td>
</tr>
<tr>
<td>Rocks very poor in Silica</td>
<td>0.0000005</td>
<td>Not known</td>
</tr>
<tr>
<td>(ultra-basic)</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Native Iron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. SEDIMENTARY ROCKS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandstones</td>
<td>0.0000014</td>
<td>5</td>
</tr>
<tr>
<td>Shales and Slates</td>
<td>0.0000015</td>
<td>11</td>
</tr>
<tr>
<td>Limestones</td>
<td>0.0000009</td>
<td>1</td>
</tr>
<tr>
<td>3. METEORITES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stony types</td>
<td>0.0000025</td>
<td>Not known</td>
</tr>
<tr>
<td>Intermediate types</td>
<td>0.0000001</td>
<td></td>
</tr>
<tr>
<td>Nicklet-iron types</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

* Radium implies 3,000,000 times as much uranium.
The Making of the Earth

increased by 3° C. The total loss of heat from the earth's surface is the product of all three factors multiplied together—area, conductivity, and gradient, and amounts to 97 million million calories per second.

Now, the problem arises, how much radium and thorium is necessary to maintain this loss of heat?

The result is most astonishing, but at the same time highly illuminating. If the rocks throughout the earth were similar to those of the crust, then the amount of heat produced would be 300 times as much as the earth actually loses. But the earth is certainly not growing hotter at this alarming rate. On the contrary, geological evidence requires that it should be slowly cooling.

It therefore becomes clear that the assumption that the whole earth contains the same average of radio-active elements as the rocks with which we are familiar is quite wrong. Either the radio-active elements must be concentrated in a thin surface shell, or at great depths they must cease to be radio-active and therefore to give out heat.

Now a simple calculation shows that the depth of the radio-active shell of average rock would be only about 10 miles thick, and we have already seen that down to 50 miles radio-activity proceeds quite unaffected by the temperatures and pressures obtaining at such depths. The conclusion is definite and certain that the radio-active elements are restricted to the earth's crust and that the interior is free from them.

We may now proceed further. If the radio-active shell is only 10 miles thick, the temperature at the bottom would be only 500° C.; and that is the highest temperature that would be possible inside the earth. Such a result is certainly wrong, for the existence of volcanoes proves that temperatures of at least 1,000° C. to 1,200° C. must exist within the earth.

There is only one way to ensure temperatures of this order. The radio-active elements must go down to greater depths than 10 miles, and since the total supply is limited they must be less abundant at some depth below the surface than they are among the granites which constitute the platforms of our continents. That is to say, under the granite rocks of the continents there must exist rocks containing less radium and thorium.

The basalt, which comes through granite areas from below, bears witness to the kind of rock to expect. It is a heavier rock than granite, with less silica, and for that reason it is called a basic rock. Below this zone of basic rock there must be rock still poorer in silica like the stony materials of meteorites. Within this "ultra basic" zone, which may be 1,000 miles thick, lies the great core of the earth. It must contain no radium or thorium, and it must be heavy. The only material which answers these requirements is iron, or the nickel iron alloy of the metallic meteorites.

Summing up, our argument is as follows:—

1) The fact that the earth is not getting hotter proves that the radio-active elements must be concentrated in the earth's crust.

2) The existence of volcanoes and the high temperatures of their lavas prove that the radio-active elements must become less abundant as the depth from the surface increases.

3) The order of the rocks from surface to centre which this distribution implies is (a) Granite; (b) Basic rock, which sometimes comes through the granite in the form of basalt; (c) Ultra basic rock like that of stony meteorites; (d) Iron, or an alloy of iron and nickel like that of the metallic meteorites.

Every line of evidence thus leads us consistently to the same conception of
The Earth's Age

the earth, a conception which is expressed in the diagram on this page, and we may therefore feel secure that it represents a very high approximation to the truth. It is a conception very far removed from the wild speculations of earlier philosophers who felt the interest and fascination of the subject, but who were, unfortunately, in the possession of insufficient knowledge to justify their conclusions.

We now know fairly well the structure of the planet whose origin we wish to investigate, and, if possible, to understand. There is one more critical feature in which the earth herself can help us. Has the earth ever possessed a molten crust?

The older geologists all believed in such an initial condition as a basal article of scientific faith. Recently, however, some doubt has been cast on the hypothesis, and we shall do well to examine it afresh. We have just seen that with a little more radium and thorium the earth would be actually getting hotter, and the existence of those heat producing elements in the rocks makes it a little hazardous to assume that the earth has cooled from a molten state.

The question, however, is really one of time. The effect of radio-activity is to slow down the normal rate of cooling, supposing that the earth has cooled, and thus Lord Kelvin's calculation of the age of the earth, as measured by the time required to cool down from a molten state to its present condition, must be very greatly increased when radio-activity is taken into account. Kelvin's method gives an age of 25 million years, which is far too low to contain the long history of the rocks which it is the object of geology to study and reveal. Now, if three-quarters of the earth's heat is due to radio-activity and the other quarter to its own initial store of heat, the rate of cooling would be slowed down, so that, instead of arriving at the present conditions in 25 million years, 1,600 million years would be required. Moreover, under such circumstances, the demands of volcanic

A SECTION THROUGH THE EARTH

All evidence leads consistently to the conception of the Earth expressed in this diagram with all the radio-active elements concentrated in the crust.

Rate of Cooling

Cooling
temperatures would be easier to obtain, for, in spite of the limited radio-activity, which provides a restricted temperature in depth, there is the temperature due to original earth-heat in addition, which goes on increasing in depth. On such a basis, volcanic temperatures can be explained far more readily than if the earth's heat is all obtained from radio-active sources.

We may therefore conclude that if the earth's age is 1,600 million years or more, then there is nothing in radio-activity to forbid belief in an earth which originally possessed a molten crust. Now, quite independently, radio-activity shows us that the earth has such an age.

Every radio-active mineral is like a clock ticking out its age as the uranium and thorium within it gradually disintegrate. Both of these elements give out helium atoms which slowly accumulate in geological time.

The rate at which helium is formed from any given quantity of uranium or thorium is accurately known, and if, therefore, we find out how much helium a mineral contains it is possible to calculate how long it must have taken for that quantity to accumulate. Unfortunately, whenever a mineral is crushed in readiness for analysis, some helium escapes, and therefore the age finally obtained is too small. The greatest age found by the helium method was 750 million years for a sphene from Ontario, Canada.

However, the disintegration of uranium does not only produce helium as a by-product; it also generates lead as the stable end product of the whole series of elements in the uranium family. The end product of the thorium series is not yet known. It is certainly not lead, and a search for it is at present being actively conducted.

Since a known quantity of uranium produces a definite amount of lead every year, the lead actually present in a mineral originally free from lead is a measure of its age. In this way the following time scale has been determined from minerals of known geological age—

<table>
<thead>
<tr>
<th></th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboniferous</td>
<td>340,000,000</td>
</tr>
<tr>
<td>Devonian</td>
<td>370,000,000</td>
</tr>
<tr>
<td>Silurian-Ordovician</td>
<td>430,000,000</td>
</tr>
<tr>
<td>Cambrian</td>
<td>—</td>
</tr>
<tr>
<td>Algonkian</td>
<td></td>
</tr>
<tr>
<td>(Igneous rocks)</td>
<td></td>
</tr>
<tr>
<td>between the Algonkian and the Archaean</td>
<td>1,000,000,000 to 1,250,000,000</td>
</tr>
<tr>
<td></td>
<td>1,250,000,000</td>
</tr>
<tr>
<td></td>
<td>1,400,000,000</td>
</tr>
<tr>
<td></td>
<td>1,500,000,000</td>
</tr>
</tbody>
</table>

The evidence from radio-activity is, therefore, completely in keeping with the hypothesis of an earth initially endowed with a molten crust.
The Earth’s Origin

A considerable amount of heat is produced during the genesis of a planet, and also afterwards, by the gravitational falling together and compression of the materials which build up the planet.

In the ease of large bodies the generation of heat in this way is, of course, much more important than that produced by smaller bodies. Jupiter is an example of the former class; the moon of the latter. The earth stands midway between them in respect of size. Jupiter and the other large sister planets all appear to be hot bodies clothed in vast atmospheres, and their densities are correspondingly low.

The moon is a cold, dead world without oceans or atmosphere. Its surface, however, is everywhere pitted with gigantic craters and fissures, from which the great lava fields of the mare have emanated. Practically the whole of its surface has been in a molten condition at some remote epoch, but being too small to hold either ocean or atmosphere it rapidly cooled down and became the inert and naked satellite we see to-day.

Now, if the moon can have been molten over much of its surface, and if Jupiter still is warm, the heat being largely retained by its thick blanket of atmosphere, it is only reasonable to suppose that the earth, being intermediate in its thermal history, also passed through a condition in which the crust was molten.

On account of its superior size, the earth was enabled to retain its ocean and atmosphere, and to generate and preserve more heat than its satellite, thus cooling down much more slowly than the moon. On account of its inferior size it has generated and preserved less heat than Jupiter, and has, therefore, cooled more rapidly than its larger sister, which still seems to maintain a high superficial temperature.

We have now learnt sufficient about the earth for our present purpose of dealing with its origin. The next important and critical feature of the problem lies in the earth’s relation to the rest of the solar system.

The earth is only one of the lesser children of the sun, and its origin cannot be dealt with except by considering that of the whole solar family. The sun does not control a haphazard collection of unrelated planets, but a regular system of bodies all lying nearly in one plane, and all, with few exceptions, rotating and revolving in the same direction as that of the sun’s rotation.

At the time when Laplace launched his celebrated Nebular Hypothesis, these latter exceptions were not known, but
The Making of the Earth

even taking them into full consideration, the solar system is found to be built on a plan so orderly and simple that it can be said to constitute a hall-mark guaranteeing the common origin of the whole.

So striking in their simplicity and uniformity are the movements and distribution of sun, planets, and satellites that the conclusion is irresistible that all were once united as a single body, which we may term the parent sun, or the parent nebula of the present system. The mathematical chances of this community of origin being untrue, in favour of a more fortuitous origin, are billions of billions to one, and this, for practical purposes, is certainty.

The genius of Laplace wrought this conception into the great hypothesis which bears his name, and which powerfully influenced scientific thought throughout the nineteenth century. Other similar generalisations had been put forward by Buffon and Kant, but their expositions lacked the mathematical accuracy and skill which the name of Laplace guaranteed.

His Système du Monde, published in 1796, was a great mathematical poem of creation in which the illustrious author attempted to trace the gradual evolution of the solar system from a hot, gaseous, spheroidal nebula, under the normal operation of natural laws.

His initial nebula was lens shaped and extended beyond the orbit of the outermost planet, rotating slowly in the same direction as the sun does now. Dispersed in such a nebula the matter of the solar system would form a thin mist of rarefied gas resembling a vacuum more than anything else, and being on the average only 1/250,000,000ths as dense as the air we breathe.

Laplace was careful to point out that the sun was already foreshadowed as a central condensation within this nebula, so that the outer parts must have been of inconceivable tenuity. As such a body contracted by the gravitational attraction of its parts, heat would be generated and the contraction would be accompanied by an increase in rotational velocity.

After a time the loss of heat by radiation into space would be balanced by the heat generated by contraction, and the subsequent history would be governed by cooling, contraction, and increasing rotational velocity. At a certain stage the centrifugal force at each point of the equator of the nebula would become equal to the attraction of gravity, and would then slowly establish a sufficient excess of force to separate a ring of gas, which would be left behind by the contracting nebula.

The same process of ring separation would be repeated again and again, and as each ring would be mechanically unstable, it would ultimately rupture and coalesce into a spheroid—the gaseous representative of one of the planets.

By the action of the same processes on a smaller scale many of the newly-born planets would themselves detach a second generation of rings, each, on aggregation, becoming a satellite.

The central nucleus, 700 times larger than all the matter swung off during its contraction, would continue to contract till the final planetary ring had been abandoned, and so became the sun. Each member of the circling family of planetary children and satellitic grand-children would have the same directions of rotation and revolution.

On this view, the earth-moon system began as a gaseous ring which coalesced to form a spheroid and then contracted until it rotated so rapidly that the moon ring separated. The earth itself thus began as a hot fluid globe with a vast atmosphere containing all the vapours of its volatile substances.

As it slowly cooled the various materials would sort themselves out according to their densities or chemical
Insuperable Difficulties

affinities, and the effect of contraction would be to squeeze out all the stony material towards the outside, leaving a central core of iron. The stony material would then itself differentiate, the lighter materials rising towards the surface, where a condition of aqueo-igneous fusion would probably persist for some time—the water of the oceans entering intimately into the fusion of the rock materials. Ultimately, as cooling progressed, the water would be able to separate and the rock material would crystallise out as granite. Atmosphere, oceans, and solid erust having thus been formed, the earth’s geological history would have begun.

Unfortunately for this majestic process, insuperable difficulties have arisen at its every stage, and so many are the discrepancies between theory and more recently demonstrated facts that the Laplacian hypothesis has been reluctantly abandoned.

In the first place, no certain case of a nebula of the Laplacian type has ever been discovered, although innumerable spiral nebulae of the type illustrated on page 29 are known.

Again, the movements of rotation and revolution of some of the planets and their satellites are now recognised to be in the wrong direction, and in addition to these awkward facts, there are the theoretical difficulties that rings of gas could not separate as postulated, and that even if they could, the resulting planets and satellites would have different orbits and velocities from those they actually possess.

Since spiral nebulae are specially abundant in the heavens, a hypothesis might expect Spiral Nebulae to meet with more success if based on that structure as
Our very life is dependent upon these glowing fire-clouds.

By way of illustration the fire-clouds are here removed to disclose the dark inner vapours.

Sunspots are holes in the fire-clouds, through which we see the dark interior.

The Sun's outer layers of metallic vapour in the theoretical section.

The Sun—on which our life depends.

The Sun's radiant energies, supporting, as they do, all forms of life on the Earth, originate from an outer shell of fire-clouds with a temperature estimated at 9,000° C. Were this brilliant shell removed, darkness would reign over the Earth, and life-activity would speedily come to an end, from the very fact that immediately within this thin shell the metallic vapour-clouds are comparatively black.

Continued opposite.
The majority of Sun-spots are nothing more than great openings, or holes, in the Sun's outer shell of light, through which we survey its inner darkness—as illustrated on the opposite page. To what depth this inner layer extends we have no means of ascertaining. Just as carbon is employed as the agent for producing the artificial light of the incandescent lamp, so in the brilliant solar shell exactly the same element is found as one of the agents of the Sun's light and heat-giving power.

A TYPICAL SUN-SPOT

Drawn by Strick Bilton, F.R.A.S.
The Making of the Earth

a model for its postulated mechanism. Such has been the case. Moreover, the earth is known at the present day to be slowly growing in bulk by the infalling of innumerable meteorites. True, the annual increase in weight is not appreciable, for 20,000 tons makes little difference to the earth. However, it indicates a method by which the earth may have developed—by the gradual aggregation of vast numbers of small bodies like the meteorites which reach us to-day from space.

A hypothesis based on such a growth is dynamically more sound than the more nebulous—doubly so—hypothesis of gas condensation. From these two standpoints, the one for the original nebula and the other for the actual growth of the earth, Professor Chamberlin has framed his Planetesimal Hypothesis.

The general structure of a spiral nebula suggests a whirling movement due to the combined forces of rapid spin and outward expulsion. From a central nucleus two spiral arms are drawn out in graceful curves at diametrically opposite points.

In the nebulous streamers luminous knots and irregularities may often be seen, the precursors, perhaps, of a system of stars similar in their distribution to that of the planets of the solar system. Seen from the side, the spirals appear as discs of misty light, although even in these cases the central nucleus may often be discerned.

Dynamically the structure is strongly suggestive of tidal action, the force, however, being sufficiently powerful not only to raise a tide such as that which twice a day sweeps round the earth, but to disrupt the material and tear it away far from its parent body.

Let us suppose that our ancestral sun was encountered in space by some other celestial wanderer. As the stranger drew near heavy tidal stresses would be set up, and these would gradually increase as the other body approached until ultimately the force would—if the stranger were more massive than the ancestral sun—overcome the gravitational attraction of the sun on its own outer shell, and explosive outbursts of matter would be violently projected.

It is well known that ocean tides rise in pairs, one on the near side and one on the far side of the attracting body (the moon, and to a less extent the sun). The diagram clearly shows that the tide-raising force on an ocean at A, the near side, is greater than that at C, the centre of the earth, and therefore the ocean is raised relatively to the earth owing to the extra outward pull at A.

At B, however, on the far side, the lunar attraction is less than at C, and thus the earth is pulled away, leaving the waters bulging outwards at B.

In the case of our ancestral sun the phenomena is dynamically similar, but so intense that the material in places like A and B would be broken away and torn off. If the original sun were rotating, the two streams of matter would swing out and begin to revolve around their disrupted parent, like the sparks from a huge catherine wheel. Thus out of the catastrophe two spiral arms would gradually emerge, fed by outbursts from within and enveloping themselves around the shattered sun.

In such a manner as this existing spiral nebulae may have been developed, and it is very probable that the new stars which we sometimes see flash out in the heavens represent the
THE BIRTH OF A NEW STAR

It is very probable that the new stars which sometimes flash out in the heavens represent the blazing flood of light and heat generated by the collision, or relatively close approach (without actual collision) of two celestial bodies.
The Making of the Earth

blazing flood of light and heat that the close approach or collision of two celestial bodies would generate. Such a nebula as that described above for the ease of our hypothetical ancestral sun seems to be adequate to meet all the requirements for the gradual evolution of the present solar system.

The material which circulates around the sun in the form of the planets of to-day only represents the one-seventh-hundredth part of the total mass of the solar system, so that the proportion of the original sun which was torn away was not high and is readily explained by the close approach of a larger star without involving the very remote chance of an actual collision.

We commence, then, with a central sun surrounded by a circulating whirl of matter which, exposed to the extreme cold of outer space, would rapidly cool down to form a crowd of meteorite-like bodies, each having its own orbit around the sun. Professor Chamberlin calls these bodies planetesimal planets or, briefly, planetesimals.

Some of the latter would be larger than their companions and would form the nuclei of the future planets and satellites. Asserting their superior attraction, they would gradually draw to themselves their smaller neighbours and so would grow by coalescence at the expense of the planetesimals within the sphere of their attraction. Circling round the sun time after time, they would sweep up all the stragglers until at last only the planets and their satellites remained.

The latter, of which the moon is the most familiar example, were evidently smaller bodies which succeeded in avoiding actual collision and fusion with their more powerful planetary neighbours, but which were captured and brought within their zone of influence. They indicate their subservienc to their masters by rotating around the planets and accompanying them in the periodic journey around the sun.

Dynamically the Planetesimal hypothesis is sound, and it successfully overcomes the embarrassing difficulties which have at last made belief in the Laplacean hypothesis impossible. Although it has not yet stood the test of a century's criticism, it is generally accepted as being the most successful and convincing attempt yet made to grapple with the formidable difficulties of so transcedental a problem as the origin of the solar system, and in particular of the earth.

We live, then, on a planet which has been slowly built up from a knot of nucleus in a spiral nebula, by the aceretion of innumerable planetesimals from without. The earth has not yet finished its period of growth, though at present the yearly infall of meteorites does not appreciably increase its bulk.

The total weight of the earth (if it be permissible so to express its mass) is 6,000 million million tons. The annual meteoritic increase is about 20,000 tons, so that even in 1,600 million years, which we may accept as the period that has elapsed since the earth attained its present size, the added weight, at the same rate of progress, would be 32 million million tons, not enough to add an inch of thickness to the earth's outer crust throughout its inconceivable long geological history.

In the following chapter we shall adopt the Planetesimal Hypothesis and discuss the development of the earth's internal structure, of the atmosphere and the waters of the oceans, of continental elevations and oceanic depressions, and, finally, of volcanic phenomena, which, more than anything else on the surface of our planet, help us to understand the gradual evolution of the earth. A. H.
3. The Evolution of the Oceans and Continents


The earth as we find it to-day, presents many fascinating problems for solution. The distribution of land and sea, or, more broadly, of continent and ocean, is evidently of fundamental geographical importance.

Before oceans are possible, however, there must be water to fill them, and wrapped up intimately with the question of the origin of the ocean waters is that of the atmosphere, the life protecting blanket which keeps the surface of our planet at a habitable temperature.

The whole structure of the earth can be very well described in terms of a series of roughly concentric shells, or geospheres, as they have been called. They are known by the following names: the atmosphere, the hydrosphere, the lithosphere, the tekto-sphere, and the eentrosphere or barysthephere.

To these may be added the biosphere, the mantle of living matter and their products which co-exists with the hydrosphere, the lower regions of the atmosphere and the upper levels of the lithosphere.

The atmosphere is the layer of gases which make up the mixture known as air, and is chiefly composed of nitrogen and oxygen, with smaller quantities of water vapour and carbon-dioxide. The amount of water vapour varies within wide limits, according to local and temporary conditions of temperature and pressure. It rises from the hydrosphere by evaporation, and with a fall of temperature forms clouds, rain or snow, so returning to the hydrosphere by way of the streams and rivers which drain the land.

The atmosphere is constantly in a state of motion familiar as wind, set up primarily by the asent of warm moist air in cyclonic regions, and the corresponding descent of dry cool air in anti-cyclonic areas.

The hydrosphere is the name adopted for all the waters of the globe, chiefly, of course, those of the oceans, but including the water of streams and lakes, and also that held in the rocks of the outer part of the lithosphere.

The lithosphere consists of the innumerable variety of rocks which make up the visible solid crust of the earth. By direct borings these rocks are known to a depth of about a mile in some places, but geologically, and especially through the agency of volcanoes, we are familiar with the materials characteristic of various depths, down to perhaps 30 miles.

Life is always present where three of the elements of the ancients—earth, air, and water—are found together, and the zone of life, which does not extend far above or below the earth's surface, is the biosphere.

Geology is chiefly eoneerned with the processes at work in moulding the lithosphere, and with the long history of the earth which is disclosed by its rocks. The processes are of two kinds. Those which have their origin in the atmosphere, the hydrosphere and the biosphere, such as those set up by wind, rain, frost, rivers, glaciers, ocean
currents and tides, and by the activities of animals and plants; all of these are termed exogenetic processes, since they represent the mechanism set up by agencies acting on the outer side of the lithosphere.

Below the lithosphere, which is chiefly made up of an outer shell of granitic rocks underlain by rocks of basaltic composition (gabbro or eclogite), lies the tektosphere, which is probably made up largely of ultra-basic rocks, like those of the stony meteorites.

It is a buffer zone, able to adjust itself by flowage under conditions of high pressure and temperature, and so to preserve equilibrium between the opposed forces of the interior and the exterior. It prevents any great accumulation of stresses which would lead to great catastrophes from within, and also the state of stagnation which would result if the exogenetic processes were left entirely to themselves.

Below the tektosphere is the central core of the earth, largely metallic in its composition. It is called the centrosphere on account of its position, or the baryosphere, because of its great weight.

It is to the interaction of the geospheres and to the exogenetic and endogenetic processes set up by them that the phenomena of the surface, which constitute the subject-matter of geology and geography, are due. We must, therefore, first attempt to explain the origin of the geospheres, for the energy changes which take place within them are largely the hereditary result
Was the Earth Ever Molten?

of the ancestral forces and energies
which made them possible.

It is unlikely that the earth was ever
in a molten condition throughout. As
it grew by the accretion of planetesi-
mals, violent collisions would con-
stantly be taking place at the
surface, and the mechanical energy
of motion would be transformed
into heat energy. Professor Cham-
berlin believes that the heat so
produced would not be sufficient,
in the later stages of the earth's
growth, to maintain the crust in
a molten condition.

This view, however, is not
generally adopted. Dr. Evans has
pointed out that as soon as the
earth was large enough to control
an atmosphere and prevent its
escape into space, that very atmo-
sphere, consisting largely of car-on-dioxide and water vapour,
would act as a blanket, keeping
in the heat newly generated, and
effectually preventing its rapid
escape by radiation.

The widespread occurrence over
all the continents of granite, and
its banded and foliated equiva-
 lent, gneiss, shows that during the
earth's early geological history,
igneous action took place near the
surface and over immense areas.
In later periods similar igneous
action has taken place at various
times, but instead of being uni-
versal it has been restricted to a
number of narrow belts over the
earth's surface. This difference
implies a progressive cooling,
pointing to a former more heated
and possibly molten condition of the
erust.

In the preceding chapter we saw that
radio-activity, combined with the great
age of the earth, suggests that an initial
molten crust was more probable than a
cold solid crust, and also that a com-
parison of the earth with the Moon and

with Jupiter points to its having passed
through a stage in which at least the
superficial zone was molten.

Let us consider what would happen
if the earth's surface were molten through-
out its period of growth. The materials
which fell on its surface would be of a
composite nature, containing predomi-
ant quantities of iron, or a nickel-iron
alloy, and ultra-basic stony material.

It is probable that the original nucleus
was largely metallic, owing both to its
superior rigidity and superior powers

ONE OF NATURE'S SCULPTORS AT WORK
The wind is one of the most active agents of Nature in
carving and shaping the surface of the earth
of attraction. At first, the iron planetesimals would tend to be attracted more than the stony ones, and when the latter fell they would be kept on the outside, owing to their much lower density. In this way the centrosphere was determined from the very beginning.

Later on, as more and more planetesimals were captured, a very complicated differentiation of the various materials would take place.

Temperature, compression of the growing earth, specific gravity, melting point, and many other factors are concerned in this process, but, briefly, it may be said that (a) temperature would fuse the planetesimals, and so make possible the separation of their constituents; (b) compression of the interior would squeeze out the lighter materials, would generate more heat, and yet, owing to the pressure, maintain the centrosphere in a highly rigid, and therefore essentially solid condition; (c) the effect of specific gravity would be to cause the heavy metallic constituents to sink downwards and the light stony materials to rise for, left to itself, the molten glass, which may be taken to represent the stony material of the earth, begins to differentiate, and the upper layers are found to become enriched in silica and alkalis, whereas in the lower layers the fusion becomes deficient in these constituents.

We may now apply these principles to the different rocks and other materials of the earth. The heavy ultra-basic rock represents the material with the highest melting point.

Iron, or a nickel-iron alloy, has, of course, a much lower point of fusion, but is much heavier. Basaltic rock has also a lower melting point than ultra-basic rock and is lighter. Granite has a
ENTRANCE TO THE STALACTITE CAVES OF PADIRAC, FRANCE

Caves provide a means of exploring some of the wonders of the underworld. Though the enormous opening here shown is only about 100 feet deep, it forms the natural gateway to a world of subterranean marvels.
still lower melting point and is also the lightest of all the materials.

Here we must pause to note a significant property of granite. Heated by itself, as we now find it, it does not form a mobile fusion, but only a pasty, viscous mass. In the presence of gases and vapours, however, especially of water vapour, the fusion point is lowered to a remarkable degree, and the melt or solution (for it can be expressed in either way) becomes increasingly mobile as the proportion of water vapour and other vapours and gases increases.

As the mass cools down, and crystallisation begins to take place, the water vapour and other gases are squeezed out like water from a sponge. The granite is said to have been in a state of aqueo-igneous fusion, and from such a fusion solid crystalline granite, liquid water, and various gases would clearly be formed—or in other words, the granite of the continents, the waters of the ocean and the gases of the atmosphere.

Now all rocks and meteorites contain water vapour and gases, and it is safe to assume that the planetesimals contained the volatile materials of the oceans and atmosphere within themselves.

Volcanoes to-day give out large quantities of water vapour, carbon-dioxide, nitrogen, and many other gases, as well as ashes and molten lava. Thus, even at the present time, we see that the growth of the oceans and the atmosphere has not yet finished.

All the water of the oceans, all the nitrogen of the atmosphere and all the carbon-dioxide represented by limestones and coal and other carbonaceous deposits could be adequately provided from the gases of the rocks within 70 miles of the surface, and therefore there is no difficulty in understanding the origin of the oceans and the atmosphere.

As the planetesimal material reached the earth, the rise of temperature would cause a certain proportion of the gases and vapours present to escape. Some, however, would be retained, and in the state of fusion which would obtain the differentiation of metal and ultra-basic rock would readily take place.

As the material was buried beneath freshly-fallen planetesimals, differentiation of the ultra-basic rock would proceed. The lightest materials, containing the constituents of quartz, alkali-felspars, and such minerals as the micas and hornblendes would, in the presence of gases and vapours, become mobile and would be constantly squeezed out towards the surface.

The material of the eale-alkali-felspars, with some pyroxenes and olivines, would also be squeezed outwards, but to a less extent. Thus, the granitic and basaltic (or gabbroid) rocks respectively would be formed, though still in a molten condition.

Most of the granite would find its way to the surface, and as it crystallised would give off its excess of gases and water vapour to add to the growing atmosphere. Below the granite and above the ultra-basic rock the basaltic rock would find its home, and below the ultra-basic zone the metallic constituents would gradually accumulate.

Each fall of planetesimals would undergo some such differentiation as this, and until the respective materials had found their proper levels the arrangement would be unstable and temporary. By the time the earth had reached its present size most of the zones would be fairly well defined, and all the igneous activity (of which vulcanism is the superficial representative) that has since affected the lithosphere has been simply a natural continuation of the squeezing-out process which originally gave the earth its zonal structure.

We have already seen that the radioactive elements are associated most abundantly with granitic rocks, and to
Radio-active Elements

a less extent with basaltic and gabbroid rocks. Natural iron is free from radium and thorium, and, therefore, all the radio-active elements of the earth must have been present in the stony parts of the planetesimals.

By far the greater proportion of them would be kept near, or carried outwards, material would be expelled towards the surface at all points. It seems more probable, however, that certain parts of the earth's surface would receive a more abundant supply than others. The former would determine the positions of the continents, the latter those of the oceans. To see how this comes about,

to the surface as the separation of the lighter rocks took place.

In this way we can explain the concentration of the radio-active elements in the earth's crust, and incidentally it may be pointed out that many valuable ores have similarly been concentrated in the upper parts of the lithosphere, where alone they could be found and worked by Man.

So far we have suggested that granite let us first examine the distribution of continental elevations and ocean depressions as they are to-day.

Looking at a map of the world, preferably on a globe, it will at once be noticed that there is a predominance of land in the northern hemisphere and of water in the southern hemisphere. In recent geological times the northern ring of land was even more complete than now, for Greenland was united to
Oceans and Continents

Europe by way of Iceland and the Faroe Islands.

At the poles, however, this contrast is reversed. The North Pole is the centre of the Arctic ocean, whereas the continent of Antarctica lies around the South Pole.

The great land masses may also be arranged in three groups of meridional continents, which link up to form a nearly continuous ring in the north, but which gradually taper out in triangular masses towards the south. The three groups are (1) North America and South America; (2) Greenland (and its submerged continuation to Europe), Europe and Africa; and (3) Asia and Australia.

Another significant point is that the northern parts of these continental groups are displaced towards the west relatively to the southern parts. Greenland and North-West Africa lie to the west of the South African meridians, North America is west of South America in the same sense, and similarly the great bulk of Asia lies westward of Australia.

The next point to notice is the fact that each great land mass has diametrically opposite to it a great sea or ocean. The case of the Arctic Ocean and the Antarctic continent is not unique. Australia and the North Atlantic go together in a similar pair. Asia, north and west of Japan, is antipodal to the South Atlantic. Europe and Africa lie opposite to the Central Pacific, North America to the Indian Ocean, and South America to the China Sea, the Western Pacific, and to part of China. The latter case is the only exception to the diametrical or antipodal relationship of land and sea.

It is quite evident that the arrangement of land and sea is by no means as irregular and meaningless as a first glance at the map might suggest. They can be partially explained by reference to two processes—(1) the contraction of the earth, and (2) tidal action. Even the discrepancies have their significance, the sunken area between Greenland and Europe and the southerly prolongation of South America (which instead of lying opposite a sea, is antipodal to China) pointing to an additional process, which will be described below.

The earth contracts as a result of cooling and internal compression, the latter producing physical and chemical changes in the material of the earth’s interior, which tend to increase its density, and, therefore, to decrease its volume.

Now, when a globe-shaped body like the earth contracts, it tends to form a tetrahedron with curved faces. This may easily be demonstrated by pumping air in and out of a globe made of very thin metal. Roughly, the tetrahedral form represents the distribution of land and sea.

Obviously, the land will occupy the
Distribution of Land and Sea

corners and ridges and the oceans the depressions between them. If we balance a tetrahedron on one point, and call that the South Pole, then Antarctica lies around that point, and the three other points are occupied by Europe, with Africa on the ridge to the south, Asia, with Australia on the ridge to the south, and North America, with South America on the around the points, and connecting them would be ridges built up of similar rocks. Beneath the contracting faces the granite would be less abundant.

In this way, when the earth had completed its growth, the nuclei of the continents would be already defined in areas characterised by thick masses of granite, areas which would be relatively

ridge to the south. Between these points and ridges lie the oceans (see p. 21).

While the earth was completing its growth, contraction, due to both the causes mentioned above, would obviously be far more powerful than now. A mechanism would thus be set up by which the lighter rocks, the granites, in their fused condition, would be forced out along the points and ridges of the tetrahedron by the four contracting faces. In this way, great elevations or platforms of granite would accumulate uplifted as a result of tetrahedral contraction and which would tend to remain uplifted because of their comparative lightness. Similarly, the nuclei of the oceans would be defined by areas which had suffered a maximum depression as the result of tetrahedral contraction, areas poor in granite, made up predominantly of heavier rocks.

Other processes, however, were at work, modifying the simple results outlined above. Tidal action had begun and its effects must now be considered.
Oceans and Continents

The earth rotates from west to east, and the tidal force, due to the gravitational attraction of the moon and, to a less extent, that of the sun, acts like a friction brake trying to drag the earth's surface from east to west. Even in the solid earth the tidal wave can be discerned by delicate instruments, but owing to the rigidity of the rocks no appreciable lateral displacement from east to west takes place, the movement being chiefly up and down.

While the earth's surface was still molten, the tidal forces might succeed in actually moving the plastic rock material, just as the tides of to-day succeed in moving great masses of water. Evidently the granite areas would suffer the maximum movement. The effect on Antarctica would be negligible, as the granite there already lay east and west around the South Pole. But in the north, where the other three tetrahedral points lay, the great granite areas would be dragged out to the west to produce a continental ring of irregular width running right round the earth, north of the Equator and south of the Arctic depression. The southerly ridges would be thickened somewhat, but owing to their inferior bulk, they would not suffer so marked a westward displacement as the great nuclei and connecting ridges of the north. As suggested by Dr. Evans, the westerly displacement of the northern continental masses is thus explained. Another feature of terrestrial dynamics must be mentioned. It has been shown theoretically by mathematics, and experimentally by studying the effects of earthquakes, that the earth is more rigid along east and west lines than along north and south lines.

Broadly, the equatorial regions are more stable than the polar regions, which are more subject to heaving or oscillatory movements. If the polar regions rise, the effect in the other parts of the earth is to produce rifts parallel to the Equator and folded mountain systems running north and south. On the other hand, if the polar regions sink, the earth is compressed along lines parallel to the Equator, giving east and west folded mountain systems, the rifts being, in that case, north and south.

Frequently, however, the directions of rifts and mountains will be determined by an upward heave of the south polar regions and a downward heave of the north polar regions, or vice versa, and thus the important structural lines of
(a) A CORAL ISLAND WITH BARRIER REEF
Formed by the accumulation of immense numbers of the skeletons of corals and calcareous algae. This process is explained in "The Origin of Land Forms and Scenery" (see Vol. II)

(b) A CORAL BANK IN THE RED SEA
Reef-building corals can only live in water which has a temperature of at least 68° F.; hence they are confined to tropical areas and to a limited vertical depth (about 150 feet)
the earth will tend to run half-way between north and south, and east and west, that is, from north-west to south-east, or from north-east to south-west.

In the adjoining diagram the line OA indicates (1) the direction of folding due to upward heave of north polar regions; or (2) direction of rift due to downward heave of north polar regions. The line OB indicates (1) direction of folding due to downward heave of south polar regions; or (2) direction of rift due to upward heave of south polar regions. The line OC indicates directions actually followed, due to a combination of forces of tension (rift) or compression (folding) acting together.

A glance at the map of the world will suffice to show the importance of these directions. Only a very few mountain ranges or coast lines run from north to south or from east to west. Moreover, it is to the special tendency of the polar regions to heave that the exceptional southerly prolongation of South America is probably due, and to it we may also ascribe the break in the northern ring of land represented by the sunken connection of Greenland to Europe under the North Atlantic.

When the earth reached its present size, the nuclei of the present continents and oceans were already determined. As the surface crust cooled down, the waters would settle into the depressions to form the primeval oceans. The atmosphere would then consist largely of nitrogen and carbon-dioxide. It is not possible to assume the presence of oxygen in the original atmosphere, because no free oxygen is ever found as a primary constituent of rocks or meteorites, nor is it given off by active volcanoes, and had there been any, it would have been greedily absorbed by the rocks which, if possible, would become oxidised.

At this stage, however, life would begin its development on the earth. How it arose we cannot tell, but for us the important result is this: as soon as the earth had been prepared by the activities of bacteria-like organisms, plants became possible and with them free oxygen. Green plants absorb carbon-dioxide and water vapour from the atmosphere, and from them build up complex organic compounds. When they have fulfilled their purpose, a little oxygen is left over and this is returned to the atmosphere. How well the plants have served us is indicated by the vast quantities of coal found to-day. All the carbon in coal was once united with oxygen as carbon-dioxide.

The atmosphere to-day contains 1,100 million million tons of free oxygen, and 300 million million tons of carbon would be necessary to reconvert this into carbon-dioxide. As a matter of fact, there is known to be at least ten times as much unoxidised carbon in the earth’s crust, showing that only one-tenth of the total amount of oxygen liberated by plant life is now in a free state.

With the existence of ocean and atmosphere, a new factor in the differentiation of the earth’s surface arose. The rocks then began to be broken up mechanically by the alternation of frost and thaw, and by other temperature changes, and by the action of rain and running water. Chemical action would lead to the solution of certain constituents in river waters, and finally, the wind and rivers would carry the broken-up or dissolved materials away from their original source to redeposit them elsewhere.
The vibratory impulses are duly recorded as they pass beneath the pendulum.

An earthquake propagates huge circles of undulations within and upon the Earth's elastic crust.

Type of Milne pendulum which records distant earthquakes.

The horizontal pendulum is so adjusted that while it oscillates under the influence of distant earthquakes, it remains unaffected by local disturbances.
HOW EARTHQUAKES IN ANY PART OF THE WORLD ARE RECORDED IN ENGLAND

An earthquake sends out waves of motion or vibrations across the earth's crust, like the circular ripples produced by a stone thrown into a pond. Passing beneath the recording pendulum, these vibrations cause it to swing according to the amount of ground-tilt. It only records distant tremors, and is not affected by local shocks. The late Professor Milne discovered how to find the distance of any earthquake from his instrument, for he showed that a shock sends vibrations along three routes, demonstrated above, and the differences of their speed enabled him to calculate the distance.
Oceans and Continents

Denudation, the wearing down of the rocks, and deposition, the building up of fresh stratified deposits, became possible, and the earth's geological history may be said to have definitely commenced.

That history is the story of a long struggle for supremacy between the exterior forces and the interior forces. Left to themselves, the exogenetic processes, of which denudation is the chief result on the land surfaces, would rapidly (geologically speaking) wear down the continents. The material shorn off would be deposited as sandstones, mudstones and shales, and limestones in a narrow ribbon on the sea floor around the continents, and thus the sea would rise and the land would be cut down, and ultimately the seas would encroach over the whole of the land surfaces, and the face of the earth would be a vast expanse of unbroken waters.

Fortunately, the endogenetic processes are also at work in the heart of our planet, and they assert themselves forcibly from time to time. The ocean basins tend to deepen owing to the sinking of their heavy floors, and the lighter continental platforms between them are left at a relatively higher level.

The great masses of sedimentary rocks which border the continents are weak compared with the massive igneous rocks on which, and between which, they lie, and as they are squeezed between the great earth segments they are compressed and buckled up into high mountain ranges. At the same time igneous materials are squeezed out from below, and they rise up around the borders of the sunken areas, fluxing their way through the folded and compressed belts, and finding a less difficult passage where fissures have rent the crust.

Mountain building and the upward movements of molten rock, movements which find their surface expression in volcanoes, are thus seen to be intimately related in that they are both due to the same deep-seated cause, the readjustment of the great earth segments due to contraction, polar heaving, tidal action and the earth's rotation.

The internal or endogenetic processes are not always at work with the same intensity. There have been periods of quiescence during which denudation and deposition proceeded with little interference, but during which the earth was slowly accumulating stresses. For a time the earth can resist, but sooner or later the stresses reach a critical point and the resistance is overcome. A great period of movement then sets in.
GLACIER AND MOUNTAIN PEAK

Notice the rugged frost-serrated peaks above (Mont Blanc du Tacul, Switzerland), the lateral feeders of the glacier (Mer de Glace), and the great crevasses which fissure the stream of ice that slowly moves towards the sea, chiselling the rocks it passes over as shown on p. 45.
Oceans and Continents

The earth segments rise or fall (more probably they all fall, but some fall more than others, leaving the latter relatively uplifted) to bring themselves into equilibrium with the new conditions. The accumulation of sediments, where they are caught between the moving segments and laterally squeezed together are vertically uplifted into mountain ranges, and vulcanism becomes active owing to the tendency of deep-seated tongues of molten rock to rise toward the surface through fissures and around the sunken areas.

After a time the stresses are relieved, the earth is in a more stable condition, another period of internal quiescence is inaugurated, and denudation and deposition proceed afresh over and around the rejuvenated continent. We may demonstrate the truth of this by surveying the geological history of Britain. Geologists have divided the history of the earth into a number of periods, determined by the sedimentary rocks formed at various times, and the fossil remains of plants and animals found in them:

<table>
<thead>
<tr>
<th>Era</th>
<th>Periods</th>
<th>Maximum Thickness of Sediments in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>CAINozoic</td>
<td>Pleistocene</td>
<td>13,000</td>
</tr>
<tr>
<td>(Modern Life)</td>
<td>Pliocene</td>
<td>14,000</td>
</tr>
<tr>
<td></td>
<td>Miocene</td>
<td>20,000</td>
</tr>
<tr>
<td>MESOzoic</td>
<td>Cretaceous</td>
<td>44,000</td>
</tr>
<tr>
<td>(Medieval Life)</td>
<td>Jurassic</td>
<td>8,000</td>
</tr>
<tr>
<td></td>
<td>Triassic</td>
<td>17,000</td>
</tr>
<tr>
<td>PALEozoic</td>
<td>Carboniferous</td>
<td>29,000</td>
</tr>
<tr>
<td>(Ancient Life)</td>
<td>Devonian</td>
<td>22,000</td>
</tr>
<tr>
<td></td>
<td>Silurian</td>
<td>15,000</td>
</tr>
<tr>
<td></td>
<td>Ordovician</td>
<td>17,000</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
<td>26,000</td>
</tr>
<tr>
<td>PROTERozoic</td>
<td>Algonkian</td>
<td>82,000</td>
</tr>
<tr>
<td>(Early Life)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARCHEozoic</td>
<td>Archean</td>
<td>82,000</td>
</tr>
<tr>
<td>(Dawn of Life)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>335,000</strong></td>
</tr>
</tbody>
</table>

The figures show the maximum thickness of sedimentary rocks deposited during each period.
Mountain Building in Britain

Note how the stratification of the millstone grit rocks (Brimham Rocks, Yorkshire) has been brought out by weathering—the softer layers being the more eaten away.

On this basis let us glance through the salient features of the history of Britain, starting with the oldest rocks and finishing with the youngest. The oldest rocks of Britain are the gneisses and schists of Lewis and North-West Scotland. They are predominantly igneous and intensely crumpled, thus demonstrating a period of great earth movement. Volcanoes were active towards the end of the Archaean, and are now represented by the rocks of Charnwood Forest, the Wrekin and the Malverns. The Lewisian gneiss was heavily denuded, and the Torridonian Sandstone, the Scottish representative of late Algonkian time, was deposited on its rugged surface.

The Cambrian, Ordovician and Silurian periods were marked by the deposition of marine deposits, with an interruption during and at the close of the Ordovician. The Ordovician breaks were not marked by notable earth movements, but that volcanic action was intense in the British area is proved by the ancient lavas of North Wales and the Lake District.

Towards the close of the Silurian period the land began to emerge and a great period of mountain building, which continued through part of the Devonian period, was begun. A great range or series of ranges stretching from Norway to Ireland was built up and is known as the "Caledonian Range." Its direction, N.E.-S.W., is followed by the compressed and folded rocks of North Wales, the Lake district and the Southern Uplands and the Highlands of Scotland.

On the continental area so produced the Old Red Sandstone of the Devonian period was deposited in rivers and estuaries and in inland seas which had been isolated and cut off by the mountain ranges. Vulcanism was again very active, and left its relics in the Cheviots, Ochils, Pentlands, and Sidlaws.
The Distribution of the YOUNGER FOLD MOUNTAINS

The Distribution of VOLCANOES

- Volcanoes: recent and late Tertiary
- Chief Areas marked by Geosyncline at beginning of Tertiary Era; also Chief Areas in which Earthquakes occur
When Greenland Joined Europe

The Carboniferous was essentially a period of marine deposition, but towards the close the sea became shallow and the coal measures were deposited. Another continental and mountain building period began and a new range, the Armorican Range, was built up. Its direction was chiefly east and west, and it can be traced from the South of Ireland through South Wales, Cornwall and Devon and thence through Belgium and Germany into Russia.

To a less extent there were north and south ranges represented by the Malverns and the Pennine Chain. British Volcanoes Arms of the sea were once again isolated and the continental rocks of the Permian and Triassic were deposited in and around them. Volcanic eruptions were active during the Carboniferous and Permian in the South of Scotland. The lavas of Renfrew, Arthur's Seat, and the Carlton Hills belong to the Carboniferous, but those of Ayrshire continued into the Permian.

Towards the end of the Triassic period the land was submerged, and the Jurassic and Cretaceous periods were marked by marine deposits, with a break at the end of the Jurassic during which much of England was land but during which no mountains were built and no volcanoes were active.

With the beginning of the Cainozoic era volcanic eruptions broke out afresh in western Scotland and northern Ireland. The lavas of Mull, Skye, and Ardnamurchan, with those of Antrim, bear eloquent witness to the intensity of this action, which began in the Eocene or Oligocene. The lava sheets of Iceland and Greenland were formed at the same time, and soon afterwards the land bridge between Greenland and Europe was broken and submerged.

To the south a new range of mountains began to arise in the Miocene period. The folding of the London basin and the sharper folds of the rocks in the Isle of Wight are our small representatives of the new earth movements. Elsewhere, however, they were of vast importance, building the great Alpine systems of mountains which extend across Europe and Asia at the present day.

We may sum up this remarkable history in the following table, which gives at a glance its outstanding features:

<table>
<thead>
<tr>
<th>SUMMARY.</th>
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</thead>
<tbody>
<tr>
<td>Recent</td>
</tr>
<tr>
<td>Pleistocene</td>
</tr>
<tr>
<td>Pliocene</td>
</tr>
<tr>
<td>Miocene</td>
</tr>
<tr>
<td>Oligocene</td>
</tr>
<tr>
<td>Eocene</td>
</tr>
<tr>
<td>Cretaceous</td>
</tr>
<tr>
<td>Jurassic</td>
</tr>
<tr>
<td>Third Permian</td>
</tr>
<tr>
<td>Period</td>
</tr>
<tr>
<td>Upper Carboniferous</td>
</tr>
<tr>
<td>Lower Carboniferous</td>
</tr>
<tr>
<td>Devonian</td>
</tr>
<tr>
<td>Silurian</td>
</tr>
<tr>
<td>First Ordovician</td>
</tr>
<tr>
<td>Period</td>
</tr>
<tr>
<td>Cambrian</td>
</tr>
<tr>
<td>Terridonian</td>
</tr>
<tr>
<td>Urpleonian</td>
</tr>
<tr>
<td>Archean</td>
</tr>
</tbody>
</table>

It will now be clear that the continents and oceans have not always had their present form. It is believed, however, that the essential arrangement of continental platform and ocean depression has not suffered any serious change of place during geological time, except perhaps in the extreme north and south.

Europe has been separated from Asia, and has been united to Greenland as a result of polar heaving, i.e. the attempt of the tetrahedral form to recover the spherical form and vice versa; and
similarly South America, Africa and Australia have been united by way of Antarctica owing to movements in the southern hemisphere.

Parts of North America and Brazil, parts of Greenland, Scandinavia and Africa and parts of India and Australia appear to have been land with only minor and temporary subsidences throughout

This has frequently taken place, alternating again and again with periods of recovery and withdrawal of the seas. The nuclei of the continents have been permanently above the sea, and practically all the chief continental areas have been permanent in the sense of being light and relatively elevated portions of the lithosphere.

geological history. Other portions of the continents have been invaded by the sea and covered with mantle after mantle of sedimentary formations at various periods. It must be remembered, however, that the ocean depressions represent a much greater volume than the continental elevations and, therefore, a slight sinking in the level of the latter, or a slight rise of the ocean floor would cause much of the continental areas to be submerged.

Similarly, some parts of the ocean floor have been permanently under water, and the sites of the ocean basins have been permanent in the sense of being heavy and relatively depressed portions of the lithosphere.

In a later chapter the various land forms, coastal types and oceanic deeps will be considered in detail, and their bearing on the evolution of the present structures of land and sea floor will be more fully considered. A. H.
4. The Distribution of Mineral Wealth

The Geographical Significance of Mineral Wealth—The Necessity of Fuel—Classification of Deposits—The Distribution of Fuels—The Distribution of Iron

The geographical significance of mineral wealth has been forcibly illustrated again and again during the last few decades. The gold rushes to Australia, California, and Klondyke, in which men from all over the world risked hardships, and possible failure and disaster, for the chance of competing in the high road to fortune, demonstrate the attractive power of valuable minerals.

Among the various factors which control the movements and settlements of men, the distribution of ore deposits takes a high place. Once the fundamental needs of food and clothing are satisfied, the additional demands of a growing civilisation begin to exert a controlling influence. Those demands are essentially for fuel and useful metals.

Fuel is necessary not only as a source of warmth and comfort, but as a source of energy for all purposes, for heating, lighting, driving machinery, for ease and rapidity of transport and distribution of commodities, for communication, and indeed for all the complex phases of the social life and economic development of the great nations of to-day.

While fuel supplies so high a proportion of the energy which lies at the root of our modern activities, so useful metals are necessary to provide the working materials. It is obvious that iron is by far the most important of the useful metals, for its abundance and strength raise it at once to the first place in structural engineering, whether applied to the requirements of peace or war.

We live indeed in an age of coal and iron. Two mighty giants of energy and strength have been enslaved and moulded to our purposes. It is, however, becoming more and more evident that their energy and strength cannot last for ever. In the case of coal, especially, the time can be calculated when, at the present
TIN MINING NEAR KWALA LUMPUR, SELANGOR

Tin was one of the earliest metals to be used by man. Entering as it does into the composition of bronze, it was known and worked in Britain and elsewhere in prehistoric times. The alluvial, "open-cast," tin mines of the Malay Peninsula are worked principally by Chinese labour.
extravagant rate of consumption, the earth's supply will have dwindled away to negligible proportions.

What will happen then? The prospect is a depressing one, and it therefore behoves us as an intelligent people to realise the undreamt-of changes which the use of coal has introduced into the world, and the colossal tragedy which may follow the cessation of its supply.

Geographically, the distribution of mineral wealth has controlled the growth and power of nations in the past, and unless a miracle of science occurs, it will control their destinies to the end of this amazing period of extravagance and luxury in which we are living.

In order to arrive at the relative importance of the chief minerals and metals the following table has been compiled from the Home Office reports, to show the total outputs throughout the world during the year 1910:

**Value of Mineral Wealth produced during the Year 1910 by the Chief Mining Countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Value in Pounds Sterling</th>
<th>Population in Thousands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. United States</td>
<td>411,000,000</td>
<td>91,972</td>
</tr>
<tr>
<td>2. United Kingdom</td>
<td>140,000,000</td>
<td>45,370</td>
</tr>
<tr>
<td>3. British Possessions</td>
<td>113,000,000</td>
<td>389,630</td>
</tr>
<tr>
<td>4a. British Empire</td>
<td>235,000,000</td>
<td>435,000</td>
</tr>
<tr>
<td>4. Germany</td>
<td>129,000,000</td>
<td>64,825</td>
</tr>
<tr>
<td>5. Russia</td>
<td>58,000,000</td>
<td>164,000</td>
</tr>
<tr>
<td>6. Austria-Hungary</td>
<td>53,000,000</td>
<td>50,000</td>
</tr>
<tr>
<td>7. France</td>
<td>47,000,000</td>
<td>49,000</td>
</tr>
<tr>
<td>8. Spain</td>
<td>21,000,000</td>
<td>20,000</td>
</tr>
<tr>
<td>9. Chile</td>
<td>20,000,000</td>
<td>3,400</td>
</tr>
<tr>
<td>10. Belgium</td>
<td>16,000,000</td>
<td>7,500</td>
</tr>
<tr>
<td>11. Mexico</td>
<td>16,000,000</td>
<td>16,000</td>
</tr>
<tr>
<td>12. China</td>
<td>10,000,000</td>
<td>400,000</td>
</tr>
<tr>
<td>13. Japan</td>
<td>10,000,000</td>
<td>50,000</td>
</tr>
<tr>
<td>14. Italy</td>
<td>10,000,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Minor States (about 50)</td>
<td>46,000,000</td>
<td>245,000</td>
</tr>
</tbody>
</table>

Total Value = 1,100,000,000 1,623,000

These tables serve to show, at the outset, the relative abundance and value of the chief kinds of mineral wealth and the relative producing capacities of the various nations. Later on in this chapter the production of individual commodities will be dealt with separately, for it must be remembered that fuel (including coal and petroleum) and iron are of outstanding importance as the most vital of the mineral necessities which ensure a country's welfare.

Gold and silver have an artificial value in relation to credit and currency, and, together with diamonds and other precious stones, an ornamental value. Their natural value, however, is of a low order and their geographical significance is temporary.

Before dealing with minerals and metals individually, some account of the origin of ore deposits may be both interesting and profitable.

We have already seen in previous chapters that rocks and land forms may all be classified genetically on a twofold grouping according as the geological processes concerned are endogenetic or exogenetic.

The former includes all processes which
The Distribution of Mineral Wealth

originate within the earth and which act from within outwards, under the influence of high temperatures. The latter includes all processes which originate on the surface of the earth and which act superficially and inwards, under the influence of comparatively low temperatures.

These two contrasting processes are represented respectively by igneous, tectonic and metamorphic activities, and by denudation and deposition. The following classification of ore deposits on this basis is a simplification of that developed by Mr. T. Crook, and, on the right, the terms by which the various types of ore deposits are generally known have been added.

A. ENDOSTEGETIC DEPOSITS.
1. Igneous Segregations ... Magmatic Segregations.
   { Pneumatolytic.
2. Igneous Exudations ... Hydatogenetic.
   { Metasomatic.
3. Ore Deposits of Thermo-
   dynamically altered Rocks Metamorphic.

B. EXOGENETIC DEPOSITS.
4. Detrital or Placer Deposits Detrital.
5. Solution Deposits ... Hydatogenetic.
   { Metasomatic.
6. Plant and other Organic
   Accumulations and their Products ... Organic.

Igneous rocks probably provide the ultimate origin of all ore deposits. Generally, however, the useful elements are either, as in the case of iron, combined with other elements in minerals from which they cannot be profitably extracted, or, as in the case of copper and tin, they are so sparsely distributed that it is impossible except by difficult and complicated chemical methods to separate them.

Ore deposits, therefore, represent masses of rock in which metalliferous minerals or other substances of economic value have been naturally concentrated to such a degree that they can be profitably extracted.

The study of the origin of ore deposits is the study of the processes by which Nature succeeds in concentrating useful substances, which for mining purposes are practically absent from the majority of rocks. As the above classification shows, ore concentration has been effected in many different ways, and ore bodies may be found, for that reason, in all classes of rocks.

It is obvious that ore deposits formed by superficial agencies must be restricted to a very thin outer shell in the earth's crust. It is much less obvious, however, that deposits drawn from the earth's interior should also be limited in their downward extension.

Indeed, not many years ago it was an attractive and commonly accepted generalisation, though a dangerous one, that ore deposits of this type were not only persistent in depth, but that their richness increased as they were followed downwards. Mining experience has not, unfortunately, borne out these rosy prophecies.

We now know that the most favourable levels for ore concentration lie between the present surface and depths of from 2,000 to 4,000 feet. Moreover, by the action of percolating ground waters the upper parts of ore bodies tend to be impoverished by solution, but as the solutions are frequently carried downwards and their valuable contents are re-deposited at variable depths up to 1,000 feet, there is generally found below the surface and above the 1,000-feet level a zone of "secondary enrichment" which increases the metalliferous yield of this zone at the expense of the overlying portions.

The fundamental fact in the distribution of ores, then, is this: the outer shell of the earth's crust, rarely more than a mile in thickness, is the storehouse in which the whole of the available supplies are contained.

A. ENDOSTEGETIC DEPOSITS
1. Igneous Segregations. — Among Magmatic Segregations, that is to say, ore deposits which owe their concep-
EMERALD MINING AT MUZO, COLOMBIA

The emerald, one of the most highly valued of precious stones, is found in Egypt, Siberia, and the United States of America, as well as in Colombia, where the finest are found. The stones are found imbedded in veins traversing slates, limestones and hornblende and cyanite schists.
The Distribution of Mineral Wealth

tation to direct crystallisation from a molten magma, the chief substances of economic importance are as follows:

(a) Gold in practically all the great gold-fields of the world, affording the source for valuable placer deposits.

(b) Platinum associated with chromite segregations in the Urals.

2. **Igneous Exudations**, containing, as the ore carriers, chemically active vapours and powerful solutions, are often responsible for the concentration of valuable ores. The exudations are squeezed out of the igneous magma as it crystallises, and permeate the surrounding rocks. Cavities, fissures, and cracks are filled

(c) Nickel alloyed with iron in New Zealand.

(d) Diamonds in the volcanic pipes of South Africa.

(e) Iron Ores in Scandinavia and Lapland.

(f) Chromite in Norway and South Africa.

(g) Corundum \((\text{Al}_2\text{O}_3)\) in the Appalachian region and Ontario in North America.

(h) Sulphides of Nickel and Cobalt in Scandinavia, Sudbury (Canada), and Namaqualand.

SEARCHING TABLES AT DE BEERS DIAMOND MINES, KIMBERLEY
Diamonds found in the volcanic pipes of South Africa, which have a great ornamental value, owe their concentration to a direct crystallisation from a molten magma

with mineral matter in the neighbourhood of the parent igneous intrusion.

When gases and vapours are the active agents in concentrating the ores, the latter are said to be **Pneumatolytic**. If aqueous solutions are the carriers the deposits are described as **Hydatogenetic**, and this term is also applied to ore deposits formed from surface waters.

In many cases it can be proved that percolating solutions bring about chemical reactions with the rocks through which they pass, depositing their metalliferous
Deep-seated Ore Deposits

load and carrying away the useless material which they have replaced. Such replacement deposits are said to be Metasomatic.

Gaseous and aqueous emanations accompany volcanic eruptions, and continue during the waning stages of volcanic activity.

The sulphur deposits of Italy, Sicily, Japan, and New Zealand, and the boric acid of the Tuscan fumaroles are instances of mineral deposits due to volcanic exudations. Among the deep-seated ore deposits, the following may be cited:

**Pneumatolytic**

*(a)* Cassiterite or Tin Stone, in all the tin-producing areas of the world—Cornwall and Devon, Erzgebirge, Spain, the United States, Malay Peninsula, Bolivia, Peru, Australia, Tasmania, Nigeria, S. Africa, etc. Wolfram (Tungsten ore) and topaz often accompany the tin stone.

*(b)* Sulphides of Copper occur in Cornwall, Norway, Oregon, Mexico, Chili, and German South-West Africa. Gold is sometimes associated with these sulphide deposits.

**Hydatogenetic**

*(c)* Gold in Australia (Ballarat, Bendigo, and Kalgoorlie), California, Alaska, the United States (Cripple Creek and Comstock), Mexico, the Transvaal, and North Island of New Zealand.

*(d)* Copper Ores in the Lake Superior region, California, and other North American localities (especially Butte, Montana), Mexico, Chili, South Africa.

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**ORES OF METALS**

The Distribution of Mineral Wealth

Australia (Wallaroo), the Rio Tinto region of Spain, and the Urals.

c) Lead and Zinc Ores in the British Isles, especially Wales, the Isle of Man, Devon, Northumberland, Cumberland, Durham, and Yorkshire, in North America, New South Wales (Broken Hill), Saxony (Freiburg), and Spain.

f) Silver Ores in Montana (Butte), Nevada, and Colorado (U.S.A.), Canada (Cobalt), Mexico, Broken Hill in New South Wales, and the Erzgebirge of Saxony and Bohemia.

g) Nickel and Cobalt Ores in Canada (Cobalt) and Hungary, Saxony and Bohemia.

h) Mercury and its Ores in Spain (Almaden), Austria (Idria), Peru, California, and China.

Metasomatic or Replacement

For convenience, all metasomatic ores will be dealt with later, as the great majority are of exogenetic origin.

3. Thermo - Dynamically - Altered Rocks. Metamorphic processes are sometimes responsible for a re-crystallisation of a rock mass leading to a purification or concentration of an older ore deposit, or to the production of new valuable minerals. The processes involved are those leading to the reconstruction of pre-existing rocks under conditions of high pressure and temperature at considerable depths below the surface. A worthless shale may thus become a crystalline rock called a schist, and any excess of alumina will form crystals of corundum, which in association with iron ores forms the valuable abrasive, emery, and which, when pure, may constitute the gem stones ruby and sapphire. The chief economic ore deposits formed in this way are as follows:—

a) Iron Oxides in Scandinavia (Dannebrog), Finland and the Urals, North America, Brazil, Rhodesia, and India.

b) Manganese Ores in Scandinavia and India, and in association with zinc ores at Franklin Furnace, U.S.A.

c) Corundum in Greece, India, Thibet, and China.

d) Copper and other Sulphide Ores in Norway, Mount Lyell in Tasmania, the Tyrol, and the United States.

e) Gold in North America and in small quantities in the crystalline schists of all the continents.

B. EXOGENETIC DEPOSITS

4. Detrital or Placer Deposits are formed by the concentration of heavy mineral fragments loosened from their parent rocks by erosion, transported by water, and deposited on the floors of valleys or on the seashore. As the velocity of the transporting current is reduced, the heavier minerals are the first to fall, and lighter, worthless minerals tend to be washed away. Deposits formed in this way thus occur in alluvium, not only in modern valleys and beaches, but in their representatives among rocks of all ages. Many valuable minerals have been concentrated in this way:—

a) Gold in all the chief gold-producing districts, notably in the Transvaal, Brazil, India, Madagascar, the United States, Alaska, Australia, and the Urals.

b) Tin Stone in Cornwall, the Malay Peninsula, New South Wales and Tasmania, Saxony and Bohemia, Nigeria, South Africa, and Bolivia.

c) Platinum in the Urals, New Zealand, Tanganyika in Central Africa, North America, and Brazil.

d) Monazite, Thorite, and other Rare Earth Minerals in Ceylon, Brazil, North Carolina, and the Urals.

e) Iron Ores (black sands) in North America and New Zealand.

f) Gem Stones, such as the diamond, ruby, sapphire, emerald, etc., in Ceylon, Brazil, and Madagascar.

5. Solution Deposits are formed by the direct precipitation of dissolved salts
Placer and Solution Deposits

from surface waters (Hydatogenetic) or by the interaction of such solutions with pre-existing rock formations such as limestone (Metasomatic). Among deposits of the first class are the following:

**Hydatogenetic**

(a) **Iron and Manganese Ores** (Black-band Ironstones and Lake- or Bog-iron Cheshire and Worcester and other localities in England, and in North America.

(g) **Borax and other Borates** in California and Nevada, Chili, and Thibet. (Due in part to volcanic exudations.)

(h) **Nitrates** in Chili and the U.S.A.

Among solution deposits of the second or replacement class are:

**Metasomatic**

(i) **Iron Ores** in the British Isles (Cleveland, Lincolnshire, South Wales, Cumberland, Lancashire, etc.), United States (Clinton group), Hanover, Luxembourg, Lorraine, and Silesia.

(f) **Lead and Zinc Ores** in the North of England and Derbyshire, and numerous areas in Europe (Sardinia, Belgium, the Alps, Silesia, etc.), the United States (Leadville, Colorado, and Nevada), and Mexico.

(k) **Copper Ores** in the Lake Superior region of North America.

(l) **Gold** in South Africa (Lydenburg) and the U.S.A. (South Dakota).
The Distribution of Mineral Wealth

6. Plant and Other Organic Accumulations and Their Products include fuels of all kinds, ranging from peat to coal and anthracite, oil shales, bitumen, and petroleum and other mineral oils. These materials are of such extreme importance that they deserve a detailed treatment.

Coal Output during 1911

<table>
<thead>
<tr>
<th>Country</th>
<th>Long Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>443,025,000</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>271,899,000</td>
</tr>
<tr>
<td>Germany</td>
<td>158,164,000</td>
</tr>
<tr>
<td>France</td>
<td>38,023,000</td>
</tr>
<tr>
<td>Belgium</td>
<td>22,683,000</td>
</tr>
<tr>
<td>World Total</td>
<td>1,160,000,000</td>
</tr>
</tbody>
</table>

Petroleum Output during 1911

<table>
<thead>
<tr>
<th>Country</th>
<th>Imperial Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>7,712,000,000</td>
</tr>
<tr>
<td>Russia</td>
<td>2,315,000,000</td>
</tr>
<tr>
<td>Dutch East Indies</td>
<td>125,000,000</td>
</tr>
<tr>
<td>Austria</td>
<td>350,000,000</td>
</tr>
<tr>
<td>Roumania</td>
<td>366,000,000</td>
</tr>
<tr>
<td>British India</td>
<td>225,000,000</td>
</tr>
<tr>
<td>Japan</td>
<td>58,000,000</td>
</tr>
<tr>
<td>Germany</td>
<td>35,000,000</td>
</tr>
<tr>
<td>Canada</td>
<td>10,000,000</td>
</tr>
</tbody>
</table>

EIGHT SPECIMENS OF MINERALS
1. Calcite (from Mexico), example of globular structure; 2. Jasper (from Ural Mountains); 3. Gypsum (from Paris), example of twinned crystal; 4. Pyrolusite (Manganese Oxide) on Lithographic Stone from Bavaria, example of dendritic structure; 5. Malachite (Tyrol), example of nodular structure; 6. Calcite (from Derbyshire), example of stalactitic structure; 7. Wavelite (from Tracton Abbey, Co. Cork), example of radiated and globular structure; 8. Calcite (from Derbyshire), example of crystals, sub-transparent

THE DISTRIBUTION OF FUELS

It has already been pointed out how dependent our present mode of life is on coal and petroleum as the chief sources of energy—that is, of fuel and motive power—and on iron as the chief constructional metal. The following tables show the outputs of coal and petroleum by the leading producing nations for the year 1911:—
Coal has obviously been derived from vegetable matter by the accumulation of the latter and its subsequent alteration. In peat bogs and swamps thick deposits of vegetable matter are being formed at the present day, and drifted wood and other vegetable remains are carried away by great rivers and deposited under water at their mouths.

Based on these present-day facts, there are two theories for the origin of coal, both of which are probably correct when applied to appropriate beds—the “growth in situ” theory, corresponding to the peat bogs (many British seams), and the “drift” theory, corresponding to deposition in deltas and estuaries (many Continental seams).

Wood, peat, and the various kinds of coal differ from each other in their relative proportions of carbon to hydrogen and oxygen. On this basis a regular series from wood to anthracite can be arranged, each member differing from the preceding by a progressive elimination of hydrogen and oxygen. This is clearly shown by the following analyses:

<table>
<thead>
<tr>
<th></th>
<th>Carbon</th>
<th>Hydrogen</th>
<th>Oxygen and Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>100</td>
<td>12.3</td>
<td>86.8</td>
</tr>
<tr>
<td>Peat</td>
<td>100</td>
<td>9.7</td>
<td>54.7</td>
</tr>
<tr>
<td>Lignite</td>
<td>100</td>
<td>8.3</td>
<td>40.0</td>
</tr>
<tr>
<td>Brown Coal</td>
<td>100</td>
<td>7.4</td>
<td>29.7</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>100</td>
<td>6.4</td>
<td>13.4</td>
</tr>
<tr>
<td>Anthracite</td>
<td>100</td>
<td>2.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

The transformation of vegetable matter into coal has taken place partly before burial (peat), but largely after burial under later sediments, and many of the changes are to be attributed to the long-continued action of heat and pressure. Under conditions of specially high temperature and pressure, caused, for example, by folding of the rocks and by igneous intrusions, bituminous coal passes into anthracite, and in extreme cases where the containing sediments are completely metamorphosed and re-crystallised, coal formations may be represented by graphite.

The oldest rocks of the earth’s crust are free from coal seams, although among the crystalline schists graphite frequently occurs. A notable bed of graphite which may be the equivalent of an ancient coal seam occurs in the pre-Cambrian rocks of Sweden.

It is in the rocks of the Carboniferous period, as the name suggests, that the richest coal deposits occur. The coalfields of the world cover an area of over 600,000 square miles, and two-thirds belong to the carboniferous formations, leaving only one-third as the product of all the subsequent periods.

It is a remarkable fact that coal has been found in the Northern Hemisphere well within the Arctic circle, and the recent explorations of Antarctica have shown that the south polar continent, in spite of its present climate, is not without some supply of coal.

The following table, compiled by Dr. Gibson, gives the distribution in time of origin and place of occurrence of the world’s chief coal deposits:

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Localities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paleozoic</td>
<td>Pleistocene</td>
<td>Peat only.</td>
</tr>
<tr>
<td></td>
<td>Pliocene</td>
<td>Peat only.</td>
</tr>
<tr>
<td></td>
<td>Miocene</td>
<td>Lignites and brown coals in Germany.</td>
</tr>
<tr>
<td></td>
<td>Oligocene</td>
<td>Hungary, Austrian Alps, Meravia, Russia.</td>
</tr>
<tr>
<td></td>
<td>Eocene</td>
<td>Japan, U.S.A., Sumatra, New Zealand.</td>
</tr>
<tr>
<td></td>
<td>Cretaceous</td>
<td>N. Germany, Hungary, Rocky Mts., Alaska, British Columbia, Manitoba, Japan, Borneo.</td>
</tr>
<tr>
<td></td>
<td>Jurassic</td>
<td>Yorkshire, Caucasus, Siberia, Japan, Alaska.</td>
</tr>
<tr>
<td></td>
<td>Triassic</td>
<td>S. Germany, U.S.A., China, Japan, Central France, South Africa, India, Australia, S. America.</td>
</tr>
<tr>
<td></td>
<td>Permian and Permo - Carboniferous</td>
<td>Two-thirds of the world’s coal and anthracite; in Northern Europe, North America, and China Russia.</td>
</tr>
<tr>
<td></td>
<td>Carboniferous</td>
<td>No coals.</td>
</tr>
<tr>
<td></td>
<td>Devonian</td>
<td>No coals.</td>
</tr>
<tr>
<td></td>
<td>Silurian</td>
<td>No coals.</td>
</tr>
<tr>
<td></td>
<td>Ordovician</td>
<td>No coals.</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
<td>No coals.</td>
</tr>
</tbody>
</table>
The Distribution of Mineral Wealth

The welfare of Britain has for the last two centuries been intimately bound up with its supplies of coal, and further with the common association of iron ores and limestones with the coal-fields.

This natural advantage, added to the political advantages of stable governments, long periods of peace and a reliable labour supply, and to the scientific advantage of a long series of mechanical inventions, has led to the extraordinary industrial and commercial success of our country. It is, therefore, of vital importance to consider the amount of coal still available in the exposed and concealed coal-fields.

A Royal Commission investigated this problem in 1901 and found that the available coal amounts to 140,000 millions of tons. According to the most probable rate of increase of home consumption and export, it is considered that the country will be faced with exhaustion in about 300 years, that is about the year A.D. 2200.

This is a most serious prospect in view of the present impossibility of foreseeing any adequate alternative source of energy. Since only about 8 per cent. of the actual energy arising from the combustion of coal is extracted for useful work, it is clear that chemists, miners, and engineers have room to suggest immense improvements in the methods of exploiting coal, and that future governments will have to develop a deliberate policy of conservation to ensure the longer economic security of our islands.

Little can yet be said about the origin of petroleum and other natural hydro-carbon fuels. It is enough to say, for the present, that the geologist connects the occurrence of petroleum in sedimentary rocks with an abundance of plant and animal remains as the source of its origin, and with certain favourable rock structures which serve as natural reservoirs, preventing its dissipation among the surrounding formations.

The table already given on p. 66 shows the distribution of petroleum as it is at present exploited. Valuable accumulations also occur along the Persian Gulf, in the valleys of the Tigris and Euphrates, in Palestine, Egypt, and south of the Gulf of Aden. North America, Mexico, Trinidad, Bolivia, Peru, and Chili all contain proved supplies.

China is probably rich in this respect, as it is known to be in coal and iron, though its fabulous mineral wealth has been little more than hinted at.

THE DISTRIBUTION OF IRON

Iron is the next most important material to be considered. The production of the metal during 1910 was:

<table>
<thead>
<tr>
<th>Continent</th>
<th>Actual Reserves*</th>
<th>Potential Reserves†</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>27,742,000</td>
<td></td>
</tr>
<tr>
<td>German Empire</td>
<td>8,084,000</td>
<td></td>
</tr>
<tr>
<td>British Empire</td>
<td>5,824,000</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>5,166,000</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>4,316,000</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>3,300,000</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>4,733,000,000</td>
<td>12,085,000,000</td>
</tr>
<tr>
<td>America</td>
<td>5,154,000,000</td>
<td>40,731,000,000</td>
</tr>
<tr>
<td>Asia</td>
<td>760,000,000</td>
<td>1,000,000,000</td>
</tr>
<tr>
<td>Australia</td>
<td>37,000,000</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>75,000,000</td>
<td></td>
</tr>
<tr>
<td>Total Reserves exceed 64,649,000,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Actual Reserves = those of mines at present working.
† Potential Reserves = those awaiting treatment after the breaking of new ground.

It is significant that the United States stands first in the production and reserves of coal, petroleum, and iron. Its exceptionally large area, and rapidly growing population and home consumption, must, of course, be remembered, but even considering these factors, it is clear that the country is wonderfully favoured in
A PLUMBAGO MINE AT KURNEGALLE, CEYLON

Plumbago, commonly known as black-lead, is principally used for the manufacture of crucibles, for which it is specially suited owing to its incombustibility. It is mined in Cumberland, in Canada, and elsewhere, as well as in Ceylon, where the primitive ladders shewn here are still used by the native workers.
The Distribution of Mineral Wealth

its native resources. Germany is well off in respect of iron, but her coal supply is poor in proportion, and her supplies of mineral oils are very low.

Our own country, for its size, is exceptionally rich in coal and iron, and although its natural hydrocarbons are not abundant, the Empire makes up for the deficiency, India, Canada, and Egypt having large potential reserves.

An interesting statement of the relative position of the British Empire and foreign countries in respect of other forms of mineral wealth is given by Mr. W. Turner. The figures represent metric tons produced during 1910:

<table>
<thead>
<tr>
<th></th>
<th>British Empire</th>
<th>Foreign Countries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>3,921,378</td>
<td>13,831,737</td>
<td>17,753,115</td>
</tr>
<tr>
<td>Lead</td>
<td>250,305</td>
<td>899,305</td>
<td>1,050,610</td>
</tr>
<tr>
<td>Copper</td>
<td>78,914</td>
<td>853,349</td>
<td>932,263</td>
</tr>
<tr>
<td>Zinc</td>
<td>194,342</td>
<td>730,880</td>
<td>925,222</td>
</tr>
<tr>
<td>Tin</td>
<td>60,523</td>
<td>56,233</td>
<td>116,756</td>
</tr>
<tr>
<td>Silver</td>
<td>1,157</td>
<td>5,548</td>
<td>6,705</td>
</tr>
<tr>
<td>Gold</td>
<td>393</td>
<td>300</td>
<td>693</td>
</tr>
</tbody>
</table>

It is easy to see that the British Empire enjoys special advantages in the cases of tin and gold. Three-quarters of the Empire’s total for tin comes from the Malay States, and three-fifths of the gold supply is obtained in the Transvaal. Diamonds, although of no vital economic importance, except to the producing country, are almost wholly in the hands of the British.

The value for the British Empire (chiefly South Africa) was £8,111,000 in 1910. “German” South-West Africa produced diamonds to the value of £1,250,000, and Borneo and Brazil to only £17,000. Except in the case of silver, the United States takes the lead in all the other chief minerals and metals.

A word ought, perhaps, to be said about the radio-active elements, uranium and thorium.

They are constantly disintegrating and giving out in the process a comparatively vast amount of energy. But unfortunately they evolve only the $1/10,000,000,000$th part of their total store in a year. If we could discover any means of making these elements part more rapidly with their energies, and if we could similarly tap the internal energies which undoubtedly reside within the atoms of the other elements, the future shortage of coal and petroleum would cease to be a serious problem.

As yet there is no known means of doing this, and to say the truth, there is little prospect of its discovery. Nevertheless, scientists are not altogether hopeless. At present we are living not on income, but on capital. We are devouring our coal resources at about a million times the rate at which Nature has stored them up.

Our civilisation is a gigantic extravagance, and is justified only by the search for knowledge which will enable us to exploit the hitherto undreamt-of sources of energy which reside in every atom, and of which the distribution, fortunately perhaps, for the future peace of the world, is universal. A. H.
5. The Distribution of Plants

Carboniferous Vegetation—Influence of Climate—Rainfall Zones—Factors of Distribution—Vertical Range of Vegetation—Methods of Distribution—Island Floras—Man’s Aid in the Dispersal of Plants—Discontinuous Floras

Although much concerning the early history of this planet is shrouded in mystery, it is almost certain that the first evidences of life were in the form of minute plants. In those far-away times we must think of the earth as presenting a hard surface of largely unbroken rocks—a peculiarly unpromising condition. Yet with the coming of moisture there appeared on the scene—from whence who can say?—a vegetation not unlike the microscopic Algae which are so abundant at the present time. It is fascinating to reflect that these simple plants, able to exist wherever there are light, warmth, and moisture, were the pioneers of all the wonderful evidences of life now to be seen around us.

To this early vegetation, and the types which immediately followed, fell the task of breaking up the rocks and preparing the way for the higher groups of plants. We do not know very much about these plants which formed the early Palaeozoic Flora, or the Era of the Alge. With the passage of time many of the species attained to considerable dimensions; those which actually lived in the water do not seem to have been vastly different from some of the seaweeds of to-day. At any rate, fossil remains of such specimens in excellent condition have been discovered in the Silurian rocks.

With the coming of the later Palaeozoic Flora, or the Era of the early types of Seed-Bearing Plants and the Cryptogams, the vegetation of the world reached a much more advanced state. The Carboniferous Period is by far the best known, and a very great deal of study has been given to this interesting formation. The spore-bearing plants (the Ferns and the Club Mosses) were very much in evidence at this time, and
The Distribution of Plants

Different species of plants vary very much in their requirements in the way of temperature, but there are certain periods in the life of every plant when a definite degree of heat is required. For instance, seeds will not germinate when the temperature is below a certain point. Nevertheless, all the plants here shown flourish within the Arctic Circle.

Formed a distinctive feature of the great forests where (as shown in the picture of a Carboniferous forest on p. 46) plant life flourished as it will perhaps never flourish again on this earth.

It has been demonstrated recently that many of the plant remains found in the coal formations are not Ferns as they were formerly supposed to be. Side by side with the true Ferns there flourished fern-like plants which have been called Pteridosperms; the remarkable point about these plants is that they bore seeds. It seems likely that these seed-bearing Ferns, as we may call them, appear to have led up to the Mesozoic Flora, or the Era of the Gymnosperms.

Then flourished an important race of plants which proved a great step onwards towards the Flowering Plants of the present day. These were the Bennettitae, a type which in modern days is feebly represented in our modern Cycads. In the Bennettitae the stamens, which bear the pollen, are produced on the leaves of the plant, but the seed-bearing structures are collected into something that is very much like a pistil. There seems every reason to think that the Flowering Plants arose as an offshoot of the Bennettitae; why the
Factors of Distribution

more ancient race has been so nearly extinguished it is not easy to suggest. The vegetation of the world is varied in the extreme; almost every part of the globe has its own particular flora which differs, and may be quite distinct, from that to be found in other quarters. The simple plants in the early days of the world were able to flourish wherever their few requirements were to be found. But many modern species are much more exacting in their needs, and it is interesting to consider some of the leading factors which have brought about the present distribution of plant life in the world.

Certainly the most important influence affecting the distribution of plants is that exercised by climate. The term climate is used in its broadest sense to embrace the intensity and characters of sunlight, in addition to such matters as the movements of the atmosphere, its temperature, and moisture. It should be borne in mind that the features which make up climate, as well as other physical conditions (aspect, temperature and moisture of the soil, etc.), are often so closely associated

ANTARCTIC PLANT LIFE

Although freezing suspends the vital activities, many plants can stand a great degree of cold. Plant growth, moreover, is accompanied by the liberation of heat, and some plants will actually thaw out in the snow a cavity in which their buds expand.
The Distribution of Plants

that it is not easy to separate their action upon the life of a plant.

The amount of illumination which a district receives will influence the vegetation to a marked degree. The intensity of light is greatest at the Equator, and steadily decreases towards the poles. In any latitude the light tends to vary locally; this may be due, for instance, to the shade of trees or owing to the fact that the rays have to pass through water. On mountains, where the air is rarefied, the light is very intense. Moisture in the atmosphere, even if it is not actually in the form of a cloud, tends to modify the amount of light. At different seasons of the year the length of the daylight varies; in the polar regions there is, of course, no night at all during part of the summer.

Green plants must have light for the formation and use of their chlorophyll. Bacteria, moulds, and the larger fungi are able to flourish in darkness; indeed, it has been shown that a strong light is fatal to many forms of bacterial life. Many green plants are, however, able to flourish where there is only a small amount of light. The eaves of Central Europe are famous for their luminous mosses. The luminosity is considered to be due to the fact that the protonema of a species (Schizostega osmundacea) have spherical cells at the ends of the branches. These act as lenses, concentrating the scanty rays of light upon the grains of chlorophyll.

Seaweeds that grow in deep water secure very little light, or at any rate the rays are greatly modified. The passage of light through water involves the absorption of red, yellow, and orange rays, yet these are essential to the green plant. Owing to the peculiar pigments to be found in red seaweeds, which are abundant in the deeper waters, the light rays are altered in their character within the tissues of the plant. To an extent, one may say that they are changed into the red and orange rays which will assist the seaweed in the manufacture of its chlorophyll.

A moderate illumination favours the development of foliage, but light has a tendency to check the growth of stems. Where the light is very intense, such as on mountain heights, the stunted habit of the plants is very marked. The species have somewhat small leaves, and many of them evidence the rosette habit of growth to be observed in certain of the Saxifragas. Another form of stunted growth is the cushion. Here the stems do not grow to any length, but branch freely close to the ground. A familiar garden subject, Silene acaulis, is a good example of a cushion plant. Such plants are known as xerophytes; that is, everything is done to keep down transpiration, a process which is stimulated by light.

The curious Vegetable Sheep (Haastia Raoulia) of the New Zealand uplands produce a dense tuft of shoots. The plant is a member of the daisy family. Another strange xerophyte is the Cug-
Effects of Temperature

*Chorbia eustacei* which is not unlike a hedgehog in its manner of growth.

Many Australian trees and shrubs are notable for the fact that they direct the edges of their leaves towards the zenith, and so keep the surfaces of their foliage away from the intense light and heat streaming down from a nearly vertical sun. The great Blue Gums (*Eucalyptus*) cast very little shade on account of the fact that their leaves are held edgeways.

Heat is a very important factor in determining the distribution of plants. The amount of heat received in any locality is largely determined by latitude; other points which will influence temperature are the grouping of sea and land masses, and altitude.

The different species of plants vary very much in their requirements in the way of temperature. As well, too, there are certain periods in the life of each plant when a definite degree of heat is required. For instance, seeds will not germinate when the temperature is below a certain point. Although the sinking of the thermometer to freezing point involves the suspension of vital activities, many plants can stand a great degree of cold.

In parts of eastern Siberia the temperature falls as low as -97° F., yet quite 200 species survive this extreme cold. A curious instance is on record of a plant which was caught in the grip of intense frost whilst in full bloom; the whole thing froze hard, and active growth was entirely suspended. Many months later, when the thaw came, the plant resumed its life just where animation had been arrested.

Closely related plants are often entirely different in their powers of cold resistance. Kerner mentions two species of Rhododendron, one of which, *R. Ponticum*, is killed by a few degrees of frost, whilst the other, *R. Lapponicum*, is able to withstand the severest cold of the northern winter.

![The Blue Gum (*Eucalyptus*)](Image)

Since the discovery of Australia this tree has been distributed by man in all the warmer parts of the world. Note the curious habit of its leaves illustrated on the opposite page.

No part of the world seems to be too hot for some form of plant life. Certain lichens which grow on desert rocks are known to withstand a temperature of 200° F.; this is not far from boiling point. Many flowering plants in the hotter parts of India flourish where the shade temperature is as high as 122° F. In the hot
springs at Carlsbad, and elsewhere, certain Algae are quite happy in water which ranges up to 170° F.

Water is essential if the plant is to continue in an active state. Although some plants, such as lichens, are able to pass into a dry condition for a while, all growth at such times will be entirely suspended. The amount of invisible moisture in the atmosphere is not without its influence upon vegetation, but of far more importance is that moisture which is precipitated, it may be in the form of dew, mist, rain, or snow. In a broad sense the rainfall of a district is the most important factor of all in the distribution of plants.

Although it is possible to divide the world up into rainfall zones, it should be remembered that there may be a considerable local variation. Such matters as nearness to the sea, the proximity of mountains, the height above sea level, will all tend to modify the rainfall of a district.

It is in the neighbourhood of the Equator that we shall find the greatest rainfall. The vegetation largely consists of evergreen forests and, with abundance of moisture and a high temperature, there is no check in the growth of plant life all through the year. The vegetation in such regions as the Amazons, the Congo, and the Malay are without rival in any other part of the world. In India—Further India, for instance—the rainfall is periodie, but it is still sufficiently heavy to induce a luxuriant vegetation which has been called the “monsoon forest.”

In the southern Sudan, Rhodesia, and parts of Brazil the climate is still tropical but the precipitation is less heavy, and there are longer intervals between the rains. Here the country is open, and a feature are the wide stretches of grass known as savanna. The rainfall is even less in Northern Sudan, Somaliland, and Central Australia; in fact, we begin to find the first signs of something like desert conditions. The plants are spinous, and have small leaves; they show pronounced xerophytic characters; in their structure and mode of growth they show special adaptations to prevent loss of moisture.

The huge family of the Aneaedas is an interesting instance.

Finally there are the regions of real desert, where there is only the specially equipped plants that are able to exist at all. In these localities the Caeti and other succulent plants are able to live on their own stores of water in between the long waits for rain.

Immense areas of grassy steppes are to be found in temperate latitudes. Of these the prairie regions of the United States and Canada, the grass lands of the Argentine, and Western New South Wales, are typical. Here the feature is a comparatively heavy precipitation of rain or snow in the winter, followed by a very dry summer. The great growing
THE KUDU PASS IN THE DRAKENSBERG MOUNTAINS, BASUTOLAND

Evergreen forests are a feature of the warm Temperate Zone. In the western regions the rain falls mostly in winter. This is so on South-West Cape Colony and Basutoland. Here the trees have small leaves. Contrast this luxuriant vegetation with the desert conditions on opposite page.
The Distribution of Plants

season is in the spring of the year, when the plains are delightfully fresh and green.

Evergreen forests are a feature of the warm Temperate Zone, which may be said to extend roughly from 30° to 45°. In the western regions the rain falls mostly in the winter; this is so on South-West Cape Colony, and in the Mediterranean area. Here the trees have small leaves, such as those produced by the Olive. In the eastern regions of the warm Temperate Zone, such as China, Japan, and the Eastern United States, the chief rainfall is in the summer. This encourages a more vigorous growth, which is evidenced in the production of plants with large leaves such as the Magnolias and Camellias.

The cold Temperate Zone, which in Western Europe may be placed between 45° and 60°, and between 45° and 50° in South-East Siberia and South-East Canada, has hot summers with plenty of rain. The region is noted for the fineness of its forests of deciduous trees; the species are chiefly Beech, Oak, Ash, Birch, etc. A little farther north of this region is the area of the Coniferous forests. In this case the trees are chiefly Pine, Fir, Larch, and Birch. With the exception of the last two, all the trees are evergreen in habit. These Coniferous forests constitute the limit of tree growth, apart from a few stunted Birches and Willows which maintain an existence still farther north.

Wind has an important bearing upon vegetation and its distribution. The effect of wind upon plant life is twofold. It induces evaporation and therefore increases the loss of moisture on the part of the plant; as well, it tends to lower the temperature of the bodies over which it blows.

In a windy situation the plant is always in great danger of losing more water than it can spare. Trees which have been planted in windy situations appear to be bent away from the prevailing winds. This is simply because the buds on the exposed side have been killed, or are not able to develop, owing to the drying action of the wind. The second effect of the wind on the plant, a loss of heat, is really the outcome of the evaporation of moisture; a body which is losing moisture by evaporation is also parting with heat. The drying action of the wind on the soil is also considerable, and this may have a serious effect upon the plants.

Thus it will be observed that in windy situations the plants exhibit xerophytic characters; every provision is made to keep down transpiration. The Edelweiss, a typical plant of the exposed mountain sides, is covered with white hairs to prevent loss of moisture.

A green plant secures its carbon in the form of carbonic acid gas from the atmosphere. Other food elements necessary for growth are obtained from the soil. The character of the soil
Character of Soil

may influence vegetation almost as much as climate. This is obvious in many parts of the world where, within a short distance, it is possible to find reedy swamps, dry pastures, and woods; it is not possible that the climate can vary much in this limited zone. The different types of vegetation are due to the varying properties of the soil.

of water present in the ground is of great importance. Some of the worst deserts in the world are barren, simply because there is no water. It is believed that a great deal of the Sahara Desert is rich in plant foods, but these cannot be used for vegetation owing to the lack of moisture.

In a soil which is water-logged there may be a physiological dryness. The

It is possible for soil to be absolutely sterile, as in the ease of quartz sand. A plant with its roots in this material would not live long; it would simply die of starvation. But there is very little sterile soil in the world; almost always there are present certain mineral plant foods in addition to humus. This latter substance represents the remains of dead animal and plant matter, which has been reduced to simpler elements by soil bacteria.

Seeing that all plants absorb their soil food in the form of solution, the amount roots of plants can only absorb their food in a very weak solution; if the proportion of the material in the soil water is too high, little moisture is absorbed. The presence of souring acids or of salt in the soil tends to reduce the amount of water which is available for the use of the plants. For instance, peat has the highest water capacity of all soils, yet the plants growing on it suffer from a physiological dryness. Owing to the presence of souring acids, water cannot be freely absorbed. In salt marshes the Glasswort (Salicornia), is a curious succulent.
The Distribution of Plants

Bog plants are largely xerophytic in habit; the soil in which they grow is sour, absorption is reduced, and transpiration must be kept down as much as possible. Sea salt in the soil has a marked effect upon vegetation; plants growing in saline situations suffer from physiological dryness. Xerophytic characters are to be noticed amongst these plants, which are known as halophytes.

On the seashore we shall find the Saltwort (Salsola), a plant with curious succulent leaves, admirably fitted for the desert conditions under which it must live. A great feature of the tropical salt-water swamps are the Mangroves, abundant throughout the warmer parts of the world. The trees with their uncanny stilt-like roots seem to revel in the salt ooze on which they grow. The Mangrove is not a succulent, but in its woody tissue there are spaces between the cells in which is stored an abundance of cell sap; in this way the plant is able to combat the physiological dryness from which it would otherwise suffer.

In some soils certain elements, of more or less value to the plant, predominate. One of the most interesting instances is that in which a soil is rich in lime. Although the action is not perfectly understood, a small proportion of lime is essential for the proper development of all flowering plants. Some plants, however, prefer a soil which is rich in lime; this is the case with a number of Orchids. Some of the most curious British species, such as the Fly Orchis (Ophrys muscifera), only flourish where there is a great deal of lime in the soil. Other plants cannot exist, or at any rate they avoid soils in which there is a large amount of lime. Some common examples are the Gorse, the Bracken, and the Foxglove.

The temperature of the soil is a matter which will have an influence on the vegetation which it supports. Thus, a dark soil will absorb more heat than a light one, and a dry soil is sure to become warmer than one that is water-logged. Where the soil is wet a large amount of the heat absorbed is used up in evaporating the water, and the ground is chilled.
Vertical Range of Vegetation

In the colder parts of the world a very wet soil is not at all favourable for a free growth of plants, largely because it is so chilled that the vegetation cannot reach a proper maturity. Settlers find that by draining the land the temperature of the soil is raised, and this makes it possible to grow many crops successfully. Naturally, where the climate is warm a soil that retains the moisture does not become so chilled, and its dampness may be of value to plant life during long intervals of drought.

The geographical range of plants is observed to the best advantage in the high mountains of tropical countries, where all gradations are to be seen, ranging from the heat of the torrid zone to the cold of the frigid regions.

The first observer to give a detailed description of this vertical range of vegetation was Humboldt, and he has left us an interesting word picture which has never been equalled. He is writing of the scenery in a mountainous region of South America, and he remarks:

"In the burning plains, scarce raised above the level of the Southern Ocean, we find Bananas, Cycadaeae, and Palms in the greatest luxuriance; after them, shaded by the lofty sides of the valleys, in the Andes, Tree Ferns; next in succession, bedewed by cool misty clouds, Cinchonas appear. When lofty trees cease, we come to the Aralias, Thibaudias, and the myrtle-leaved Andromedas; these are succeeded by Bejarias abounding in resin, and forming a purple belt around the mountains. In the stormy regions of the Paramos, the more lofty plants and showy flowering herbs disappear, and are succeeded by large meadows covered with Grasses, on which

A TYPICAL "BAYOU," OR CREEK-SWAMP, ALABAMA

The roots of plants can only absorb their food in a very weak solution. Plant foods are abundant in the Sahara Desert, but they are useless there for want of water to dilute them

the Llama feeds. We now reach the bare trachytic rocks on which the lowest types of plants flourish. Parmelias, Leeidias, and Leprarias, with their many coloured sporules, form the flora of this inhospitable zone. Patches of recently fallen snow now begin to cover the last efforts of vegetable life, and then the line of eternal snow begins."

In mountainous districts in the tem-

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The Distribution of Plants

In temperate regions there is not quite such a variety of plants to be observed, but the changes are very striking. During an ascent of the Alps, for instance, one starts in the midst of warm vineyards, passing through forests of Oaks, Sweet Chestnuts and Beeches, until, at an elevation of about three thousand feet, these trees are all left behind. Forests of Fir and Birch extend upwards to a height of nearly 5,000 feet above sea level, after which no trees will be found.

The Rose of the Alps (Rhododendron ferrugineum) covers huge tracts of land at the high altitude of 7,000 feet, and a few creeping Willows manage to exist at even a higher level. Still higher up are to be found some Saxifragas, Gentians, and species of Grass, whilst the Lichens and Mosses struggle upwards to the line of eternal snow.

An interesting point in the distribution of plants is that certain kinds of vegetation will only grow in association with other species. The benefits derived surrounding Grasses. The saprophytes, which live on rotting organic matter, are indirectly dependent upon the plants with which they associate.

The strange Bird's Nest Orchid (Neottia nidus-avis), to be found in moist shady woods, relies for its food supply upon the rotting leaves of the trees beneath which it grows. In the case of epiphytes there is no actual connection between the host plant and the guest. In temperate latitudes large numbers of Lichens and Mosses grow on trees, but generally speaking they lead an independent existence. The epiphytical Orchids may be one-sided; this is generally the case with parasites, saprophytes, and epiphytes (defined below).

An advanced parasite such as the Dodder (Cuscuta) does no good to the host to which it is attached, and often will bring about the destruction of its victim. Parasites of this type do not need to be rooted in the soil or to bear leaves, for all they require in the way of food material is absorbed from the host plant.

Of course there are a large number of partial parasites, such as the Yellow Rattle (Rhinanthus), which has roots and bears green foliage; yet for part of its nutriment this species relies upon other plants. The roots of the Yellow Rattle are attached by sucker-like processes to the roots of surrounding Grasses. The saprophytes, which live on rotting organic matter, are indirectly dependent upon the plants with which they associate.

The strange Bird’s Nest Orchid (Neottia nidus-avis), to be found in moist shady woods, relies for its food supply upon the rotting leaves of the trees beneath which it grows. In the case of epiphytes there is no actual connection between the host plant and the guest. In temperate latitudes large numbers of Lichens and Mosses grow on trees, but generally speaking they lead an independent existence. The epiphytical Orchids

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**VEGETATION ZONES OF LATITUDE AND ALTITUDE**

*By permission, from Herberstein's "Outlines of Physiography" (Edward Arnold)*

On the high mountains of the tropics where all gradations of temperature, from the torrid to the frigid, are to be found, vegetation is distributed in zones corresponding to those found between the Equator and the poles.
MAGNOLIAS AND SPANISH MOS.

In the eastern regions of the warm Temperate Zone, such as Japan, and the Eastern United States may be seen a vigorous growth of vegetation. This is evidenced in the production of trees with large leaves, such as the Magnolias and Camellias; and many epiphytic plants, such as the amazing Tillandsia, which, though it resembles exactly the Usnea lichen of West Africa, is, in reality, a near relation of the Pineapple.
The Distribution of Plants

An interesting point in the distribution of plants is that certain kinds of vegetation will only grow in association with other species. This dependence of plants upon one another is known as symbiosis.

Some plants are positively helpful to others, largely on account of the fact that they are able to prepare the soil. Thus on moorlands the Reindeer Moss (a lichen) (Cladonia rangiferina) and some of the Hair Mosses (Polytrichum) will act as pioneers for Ling and Heather. Then the Bracken is able to colonise, whilst finally Birch and Pine seedlings spring up in all directions. These trees may develop so that actual woods are formed, and the vegetation of the district is much changed. The Lichens, Mosses, and Heaths almost disappear, and the few plants which are able to thrive under the shade of trees take their place.

In many cases the insects in a district play an important part in the distribution of plants. In the first place a species may be absolutely dependent upon the good offices of some insect agent if it is to complete its life cycle.

There is no more striking illustration than the case of the Yucca filamentosa of North America. Here the pollination of the flower can only be carried out by a solitary moth — Pronuba yuccasella. Where this moth is not to be found the Yucca can never produce fertile seed, unless it is artificially pollinated as is sometimes the ease in gardens. An instance of this nature is not common, and few plants rely upon the aid of a single species of insect. There are, however, a large number of flowers which cannot be pollinated save by a certain class of insect.

Larger animals also play an important part in dispersing seeds and fruits. An immense variety of methods have

EPHYTYC PINEAPPLE-LIKE PLANTS, CUBA

LICHENS

The Lichens play a large part in breaking up the surface of rocks and preparing the situation for flowering plants...
How Animals Help

been employed, and it is not possible to give more than a summary. A common practice is the allurement of an animal by means of a luscious fruit. The seeds may or may not be eaten, but in the latter event they come to no harm providing they are not actually crushed up. The pips of an apple, for instance, are able to withstand the action of the digestive juices without injury to their powers of germination.

In some cases a certain number of the seeds may actually be destroyed, but the sacrifice is not in vain. Creatures, such as squirrels, are in the habit of making winter stores of foods, and these provident animals usually put away far more than they need. Not all the nuts are eaten, and some of those which survive may grow up into trees.

In another direction animals unconsciously serve plants in the dispersal of their seeds. The number of seeds which are embedded in mud is often very large indeed. From six and three-quarter ounces of mud, Darwin germinated no less than 537 plants. Some astonishing migrations of plants can be attributed to the fact that the seeds had been carried about by birds.

Several years ago a species of Indian Grass (Coleanthus subtilis) suddenly appeared on the edges of ponds in southern Bohemia. The same plant was noticed in the west of France. Without a doubt the seeds had been brought by birds.

Many fruits and seeds are in themselves of an adhesive nature. The seeds of the Meadow Saffron become viscid when they are wetted, and in such a condition they will adhere to the feet of cows, horses, and other animals. The calyx protecting the seeds of the Plum-bago is covered with sticky hairs; these fasten on to any object they may touch. A large number of fruits are adorned with hooks, and become readily attached to any passing animal.

Many common British plants have adopted this method of seed distribution. Good instances will be found in the seed vessels of the Burdock, the Cleavers, and the Agrimony. The arrangement acts very well indeed, and anyone walking in the country at seeding time will soon find his garments covered with hooked processes which cling most tenaciously. These native species are carried about with little inconvenience; but this cannot be said to be the ease with exotic fruits.

The Martynias of South America are armed with huge hooks that may be five or six inches in length. Observers say that these hooks cause an immense
amount of suffering to wild life, for they plunge into the flesh of the unhappy creatures who unwillingly take on the task of distributing the seeds of the Martynia. In many cases it is declared that the animal will not be able to rid itself of its burden for a considerable time, and terrible wounds are produced. During this interval the creature will have travelled some distance, and thus a distribution is secured.

In some ways the fruit of the Grapple Plant (*Harpagophyllum procumbens*) of South Africa is even more remarkable. The seed vessel is covered with great hooks, and these are exceedingly difficult to dislodge once they have secured a hold. It is stated that the Grapple Plant fruits bring about the death of lions in the following manner. The terrible seed vessels frequently attach themselves to the feet of deer, and the animals are so badly lamed that they fall easy victims to the lions. But a dreadful fate awaits the king of beasts, for whilst he is taking his meal he is likely to get a Grapple Fruit in his mouth. Once firmly fixed in the jaws it is almost impossible for the lion to rid itself of the hideous burden; eating is impossible, and the noble beast dies sooner or later of starvation.

The winds of heaven play a big part in helping the dispersal of plants. In some cases the whole plant is detached from the soil as the fruit ripens, and is carried before the wind for a great distance. A typical plant is the so-called Rose of Jericho (*Anastatica*) a cruciferous species which is common in Syria. In other instances, parts of the plant may become detached, such as is seen in some of the species of Sempervivum, which are so common on mountain ledges. These offshoots take root when they reach a suitable resting place.

Even more singular is the case of the Candle Plant (*Kleinia articulata*) where the succulent branches tend to break off, and after these have settled in a good position they will take root and develop into mature plants.

The distribution of fruits, seeds, and spores by wind is a common method of dispersal. The spores of ferns, mosses, and fungi are comparatively light, and these may travel a considerable distance before settling down.

A large number of fruits and seeds are specially equipped for aerial journeys.
Many families of land plants possess genera or species which have adapted themselves exclusively to an aquatic existence, while their near allies may flourish in sandy deserts. These Water Crinums of West Africa are a member of the Amaryllis family, which gives us also the Narcissus, the Snowdrop, and the Agave.
The Distribution of Plants

The seeds of many species of Orchid are so small that they resemble dust; these will remain suspended in the atmosphere for a long while, during which time they may be wafted by the breezes far afield. In the case of many larger seeds special appendages have been developed to check a fall to earth until some distance has been traversed. In some instances, such as those of the Clematis and the Dryas, the seeds are attached to a long feathery process.

In a large number of cases the grouping of the hairs resembles a tuft (botanically, a pappus), and, in many ways, this seems to be the most successful plan of all. Plenty of examples are to be found amongst our native flora. Everybody is familiar with the beautiful flying fruits of the Dandelion, Colt’s Foot, Goatsbeard, and a great many of the Thistles. Now and again the hairs surrounding the seeds are very abundant, as in the case of the Cotton Plant of commerce.

The manner in which these flying contrivances are produced is very varied, and it is interesting to gather ripening seed heads of Dandelions, Thistles, etc., and watch the aircraft develop. In the case of relatively heavy seeds a prolonged flight through the air is often secured by the attachment of a wing-like appendage. The fruit of the Synea more is an excellent instance; without the wing-like expansion this would fall straight to the ground. The appendage really works in two ways. If there is a strong breeze blowing when the fruit leaves the tree, the process planes away upon the wind. Ultimately, when the aerial conditions are less disturbed, the heavy fruit gravitates down so that the wing is brought upwards; the wing then starts to revolve as the whole contrivance falls. The moving blade prevents a speedy fall, and all the time the fruit is still journeying farther afield.

Familiar trees bearing fruits with winged appendages are the Hornbeam, the Pine, the Ash, and the Lime. In this latter instance it should be noted that it is a bract on the flower stalk that plays the part of a wing.

The actual distance to which aeroplane fruits and seeds may be carried by the wind has been a matter for conjecture. That very long distances over the sea are not travelled in this way is evident from the fact that the proportion of flying fruits and seeds in island floras is not large.

Water is an important agent in the conveyance of plants and their fruits and seeds. The Frog Bit (Hydrocharis mor-sus-ranae), a floating aquatic, detaches buds at the approach of winter. These at first sink to the bottom, but with the
SOME METHODS OF DISTRIBUTION

1. The Dandelion is typical of the flying seeds.  
2. When the winged fruits of the Californian Pine (P. Coulteri) knock against an object the seed drops to the ground.  
3. Some large tropical flowers depend upon humming-birds for the transference of their pollen.  
4. The seeds of the Bulrush are carried to a great distance by the wind.  
5. The seed cases of the Martynia inflict terrible wounds upon the unwilling animals which help to distribute the plant.
The Distribution of Plants

eoming of the spring they rise to the surface and develop as new plants. During this process they may have floated a long distance from the parent plant. Of course, a large number of water plants are inclined to float, and these may be transported many miles down a river or a stream, and in this way distributed over a wide area. The pretty Water Buttercup (Ranunculus aquatilis) spreads down a stream 'in a wonderfully short time.

One of the most striking illustrations is that of the Canadian Water Weed (Elodea Canadensis), a plant which somehow was introduced into Britain well within the last hundred years. Yet it has contrived to spread throughout the entire waterways of our island, and in many districts has proved to be a real nuisance on account of the way in which it blocks up canals.

In many cases the seeds of plants which are not actually aquatic in habit have been specially adapted for water transit. The nuts of the common Alder, a tree which grows commonly on the banks of rivers, are provided with special water-tight compartments to ensure that the fruit shall float when it falls into the water.

Many tropical plants are famous for their navigator seeds; these are often conveyed immense distances by ocean currents. The most famous is the Coconut. As it falls from the tree, the nut is surrounded by an immense mass of tough fibres which are enclosed in a smooth white skin. This gives the Coconut sufficient buoyancy to ensure that it will remain afloat for a very long time; meanwhile it may journey on an ocean current to some distant spot.

In this way the Coconut Palm has been
Navigator Plants and Sea Flora

distributed all over the tropies, and it is usually the first plant of any size to appear on the tiniest projection of coral reef. The distance travelled by these navigator fruits, of which the Coconut is only one type, is very considerable. On the coasts of Norway there are places where it is a common experience to pick up tropical fruits and seeds, many of them quite suitable for germination. These will have been brought by the sweep of the Gulf Stream all the way from the Gulf of Mexico, a distance of fifteen and six thousand miles.

The curious sea Coconut, *Lodoicera sechellarum*, was known as a fruit which was often picked out of the sea by sailors long before the home of the palm was discovered in the Seychelles.

Plants which actually live in the water, such as Water Lilies, produce fruit in which a certain amount of air is entangled. The process is thus sure to float for a considerable time. Floating seeds and fruits may remain for a long time even in salt water without injury. Some seeds of a tropical strand plant, *Ipomea grandiflora*, were soaked in sea water for a whole year at Kew, and yet they germinated freely when planted.

In the sea the number of Flowering Plants is very small; in all the world there are certainly not more than thirty known species. Of these the Grass Wrecks (*Zostera*) are typical. These plants spread amazingly by reason of their dense network of stems, which travel in all directions through the mud.

The Grass Wrecks are remarkable for their pollen, which, being of the same weight as the water, neither rises nor sinks but floats to and fro until it reaches the stigma of another flower.

The Algae which form such a feature in the flora of the sea are largely distributed by means of offshoots. In rough weather fragments of the plants of Seawrecks, Ulvas, and Florideae are torn away. These are conveyed by the water to fresh situations on some rocky coast, or are embedded in the sand. The schemes of reproduction to be observed in the case of Algae, both freshwater and marine, involve the development of certain bodies (the zoospores of the Ulvas are a type) which escape into the water and journey for a considerable distance before they finally settle down and develop into a fresh plant.

By its own effort the plant can bring about a limited distribution of its seeds and fruits. The well-known sling fruits are interesting instances. Here, with the drying of the fruits, the tissue round the seeds is rendered highly tense. Eventually there is a sudden rupture, and this has the effect of expelling the seeds with great violence.

Examples of this are to be found in the Squirting Cucumber (*Momordica elatum*), the Balsam, and the Broom. The most striking case is that of the Monkey Box Tree (*Hura crepitans*), in which case the seeds are expelled with such
The Distribution of Plants

tremendous force that they will inflict serious wounds on passers by. The seeds of the Monkey Box tree have been carried to a considerable distance, sometimes as far as fifteen or twenty yards. This is probably the utmost limit that any plant can project seeds.

It is obvious that there is a great element of chance in the distribution of plants by natural means. All kinds of things may happen to prevent a particular seed from being dispersed in the manner it is most fitted for. The wastage is simply colossal, but the balance is well maintained by the astonishing liberality of the means of propagation.

It is simply amazing to consider the proportions on which some plants would increase if they could do so without hindrance. It has been estimated that the average Henbane plant produces 10,000 seeds in one year. If all these grew into plants, and each new specimen was responsible for a like number of seeds, we should, according to Kerner, in five years get a total of ten thousand billion plants! The gigantic figure does not convey much to the mind, but there would be more than enough of the Henbane plants to cover every square yard of dry land in the world.

The ease of the Flixweed (Sisymbrium Sophia), illustrated diagrammatically on p. 91, is even more amazing. Kerner has placed it on record that the normal multiplication from a single parent would, if unchecked, cover an area 2,000 times as great as all the dry land in the world in the period of three years. Estimates which have been made concerning the number of spores produced by cryptogams are even more staggering. Thus a single frond of a tropical fern (Angiopteris) is considered to bear four thousand million spores.

With excellent means of dispersal, and plenty of seeds and spores to distribute, it is not surprising that no part of the world where plant life is possible can long remain uninhabited. The great volcanic outburst of 1883 amongst the Sunda Straits islands (of which Krakatoa is the largest), gave the world a fascinating instance of the way in which a sterile desert can be populated with plants.

During the year in question severe volcanic outbursts absolutely destroyed the dense vegetation for which the islands were famous. When the island was sufficiently cool to visit, it was found that the soil had been completely sterilised on Krakatoa, and that there was nothing save a desert of rocks and ashes. The nearest living vegetation
Plant Emigration to Krakatoa

The Prickly Pear (Opuntia) was at least twelve miles away on the islands of Java and Sumatra. Successive visits were paid to the desolated island, and the results of the inspection may be briefly stated. Three years after the disaster colonies of Algae had established themselves on the rocks. These had been borne by the wind in a desiccated condition. In due course, the pioneer plants had so broken up the surfaces of the rocks that a suitable medium for the development of the spores of Mosses and Ferns was provided. These spores had been wafted on the breezes from Java and other islands. On the beach were discovered a large number of fruits and seeds of flowering plants, and a quantity of these were able to germinate and develop.

Most of the species were those which are commonly found on the shores throughout the Malayan region; with-
TREE FERNS, GRENADA

It is simply amazing to consider the proportions on which some plants would increase if they could do so without hindrance. It has been estimated that the number of spores produced by cryptogams are staggering. Thus a single frond of a tropical fern (*Angiopteris*) is considered to bear four thousand million spores.
The Flora of Islands

for transit to an ocean island is water; carriage by wind must be given a second place, whilst animal agency is the least useful of all.

Although invasion from overseas by plants can be effectively carried out on many occasions, the ocean may be a very formidable barrier. Island floras almost always present some interesting features. As a rule, much depends upon the way in which the island originated.

In the first place, we may consider the question of the continental islands. These are never far distant from the mainland, to which at one time they were joined, and they are still united to the continent by a submerged platform over which there is rarely a great depth of water. On an island of this nature, of which we may take Great Britain as typical, the flora will resemble the plant life to be found on the adjacent continent. As a matter of fact, there are no very distinct species of plants to be found in Great Britain which do not also occur somewhere in Europe.

On the other hand, continental islands may be ancient in origin. They may have been isolated from the mainland for an immense period. In such cases the dividing sea will be deep, sometimes as much as one thousand fathoms—that is, more than a mile. Examples of ancient continental islands are to be found in Australia, New Zealand, and Madagascar.

The vegetation on these islands came from the mainland, but so long ago that at the present time it is very different. An insular flora is not exposed to the same competition as the plants which have to fight the battle of life on the mainland. Where there is a wide expanse of sea an invasion of the continental forms may never be a serious affair. Thus, on ancient continental islands, a feature of the flora are the endemic plants. These are often the survivals of races which have gone under in the great struggle for existence which is going forward on the continent.

Quite different from the continental island is that of the oceanic type. These are commonly to be found in water of immense depth at a considerable distance from any mainland. Their mode of origin is volcanic, or they may be due to coral formation. Such islands must rely for their vegetation upon what the ocean currents, the winds, and the birds can bring.

An extremely interesting question in connection with the dispersion of plants is the part which man has played. A large number of plants have been conveyed from one part of the world to another on account of their economic or ornamental value. It is difficult to say how long this kind of thing has been going on, but the distribution of many useful plants was started a very long time ago.

The Olive and Fig have been valued by man for an immense period; these plants have been gradually conveyed to almost every part of the world where the climate is at all suitable. Probably they found their home somewhere in the warmer parts of Western Asia, but we know very little about the early history of these interesting trees.

It is more easy to follow the movements of plants which are known to be natives of the New World. The Prickly Pear (*Opuntia*), in one or other of its numerous forms, is a most interesting subject in this connection. The Spanish explorers were the first to bring American plants to the Old World. Probably the Prickly Pear was included in an early batch, as its curious growth and the fact that it bore a delicious fruit would attract attention.

This is not much more than four hundred years ago, yet there is no part of the warmer world where the Prickly Pears have not become a regular feature of the flora. This is so much the case
The Distribution of Plants

that not a few artists, who obviously know more about painting than plant distribution, have been led to make bad blunders in their work. The Prickly Pear is abundant in Palestine at the present time, and some of the most famous pictures of Bible scenes introduce the plant as a feature of the vegetation in those days. Now this is quite wrong, for it is certain that the Opuntia or any of the Cacti at all, for that matter, were not to be found apart from the New World save within the last four centuries.

Although the precise date of the discovery of Australia is not known, it was probably made at a somewhat later period than that of America. Yet Australian plants which have appealed to man as useful or beautiful have been distributed all over the world.

The great Blue Gum Trees (Eucalyptus) have made themselves entirely at home in the warmer parts of Europe, Asia, Africa, and America. The same is true of the beautiful Acaeias, commonly called Wattle; these plants are a wonderful feature of the Riviera flora in the spring of the year, as all visitors to the Côte-d’Azur can testify.

The introduction of plants by man is not always attended by happy results. The well-known story of the Scotsman who carried the Thistle plants to his new home in Australia may or may not be true. Anyhow, someone introduced the weed into the Island Continent. The forces which keep this plant in check in Britain seem to be lacking in Australia, where the Thistle has matters all its own way. Within a few years the plant had become such a plague that it was found necessary to pass an Act of Parliament “against the growth of Thistles,” and all persons who allowed these weeds to grow on their land, or even on that half of the road for which they were responsible, were liable to be very heavily fined.

The case of the Bathurst Burr (Xanthium) is even more singular. This plant, unlike most of the Composite tribe to which it belongs, has no hair on its fruits. Instead, the outside of the head of flowers is covered with hooks. These seed heads are certain to become entangled in the woolly coat of any creature that may happen to brush up against the plant.

At first the Xanthium does not seem to have had a very wide distribution apart from certain localities on the Continent. For instance, the species was not known in the Crimea in 1814, but by 1856 it had spread over the whole of the Peninsula. By 1860 there was hardly any place in Europe where the plant had not appeared.

About the same time, an observer in Chile states that the manes and tails of horses were so matted with the burrs of the Xanthium that the creatures had a difficulty in getting about at all. A little later the pest was working fearful havoc in Australia, where the presence of the burrs in the wool caused terrible losses to sheep farmers.

The introduction of the Xanthium
Discontinuous Flora

into South Africa is believed to have come about through a shipwreck. A cargo of wool on the way from Australia to Europe was driven ashore on the Cape coast. Some of the fruits of the Xanthium were in the wool, and the pest soon made itself at home in the colony.

A rather curious fact which has been pointed out is that it is almost always the European weeds which are the most successful colonists and, as a consequence, bring about the biggest amount of trouble. So aggressive are these invaders that in some quarters of the world they actually threaten to drive out the native vegetation. In parts of South America such weeds as the Shepherd’s Purse, Thistles and Nettles, far outstrip the local plants in vigorous growth.

Almost all the original flora of St. Helena has disappeared before the newcomers which came on the scene with the advent of man. The reason for this vigour of growth on the part of plants of European origin is not entirely clear. One suggestion that has been made may be a partial explanation.

The Palæartie region, comprising Europe and Asia, is by far the largest of the natural continents, and there are not many serious barriers to check free communication. As a consequence, the battle for a place to live and grow has always been severe on account of the numbers which engage in the struggle. The types which do triumph are extremely fit, and these are able to hold their own against all comers. This hardiness stands the plants in good stead when they have to start an existence in distant countries.

Some of the most remarkable groups of plants in the world are those which are commonly described as discontinuous floras. These communities are only to be found in certain positions, often widely separated from one another; in the intervening spaces the same kinds of plants do not occur at all.

The reasons why these plants do not spread are often quite clear, and may be such matters as mountain ranges, unsuitable climate or soil, or wide stretches of sea. This does not in any way explain the presence of these collections of plants. In practically all parts of the world the Alpine flora is very similar. On the mountain heights of New Zealand many of the plants differ only slightly from those which are to be found in the Highlands of Scotland.

For an explanation we must go back to the past history of this earth. The most reasonable conclusion seems to be that at one time in the world’s history the climate was entirely Arctic. Then came a change; warmer conditions prevailed, and the Arctic plants were exterminated except in the cold and mountainous regions. These isolated groups of Alpine plants dotted all over the world are the remnants of a flora, some say Scandinavian in origin, which at one time dominated the earth.

An interesting group of plants occurs in the south-west of England and in Ireland. This is known as the Lusitanian flora, the name being derived from Lusitania, the old term for Portugal. The most striking plants included in this group are the Strawberry Tree (Arbutus unedo), the Cornish Heath (Erica vagans), and some Pyrenean Heaths, two species of Butterwort (Pinguicula grandiflora and P. lusitanica), London Pride (Saxifraga umbrosa), and a few other species of minor interest. Visitors to Cornwall and the south-west of Ireland should always be on the lookout for these plants.

How shall we account for their presence in the British Islands? It is within the bounds of possibility that a plant such as the Strawberry Tree may have been introduced through the agency of birds, the ripe berries being largely consumed by these creatures. This theory does not explain the presence of the other plants, and it is not very
The Distribution of Plants

More astonishing still is the case of a small group of plants which is found in Ireland but nowhere else upon the Continent of Europe. The nearest place in which these species do occur is in North America!

These plants are three in number, and are worth mentioning on account of their importance. They are: *Spiranthes Romanzoviana*; *Eriocaulon septangulare*; and *Sisyринchium angustifolium*. How did these plants travel across the broad Atlantic, for it is not likely that they were brought by human agency over the water? Some people have conceived that they carry us back to the time when "the lost continent of Atlantis" linked up Europe with America. A solution may be found in the theory that in pre-Glacial periods the land was continuous from the north of Scotland to Iceland, from thence to Greenland, and from Greenland to America. The complete history of these three small plants would explain much. S. L. B.
6. The Distribution of Animal Life


WHAT is life?

Life for the purpose of this work might be defined as matter possessing consciousness and therefore able of itself to control and direct its movements; matter with the power to move of its own volition; matter capable of growth by the absorption and assimilation of other compounds. Living matter, we might add, in a more speculative manner, would seem to be an agglomeration of cells which can either generate mentality or a "soul," or become the home of this mysterious "will power," which may or may not exist outside living matter, but which we can only recognise as a force when it emanates from the sentient organism.

Whether there is any inherent volition in the widely diffused atoms which constitute gases, or in those which in a much denser concentration form metals or minerals; whether consequently there is any power of assimilation and growth in these so-called inanimate substances, we do not yet know. It has been hinted more than once of late in the discoveries of chemistry that the principle of life may not be entirely confined to what we know as animals and vegetables, but may in a lesser degree pulsate through other forms of matter; even, it may be, through the earth itself.

Up to the present stage in the development of astronomical research we are not in possession of evidence that suggests the existence of conscious, living matter anywhere outside the surface of the tiny planet on which we dwell, and of which we are the most amazing form of life.

It would be rash to deny that the whole remainder of the universe (which to our planet is in unestimable proportion of—say—a quintillion to one) is devoid of life. It would be equally rash to
The Distribution of Animal Life

assert that there are living forms on any other planet of the solar system or of the systems of the other innumerable suns of the universe.

But life as it can be defined by us—this combination of salts, minerals and water, and the intangible quality of volition—could hardly find the necessary conditions for its existence on any other planet of the solar system except the Earth; though the conditions on Venus or Mars may not be entirely opposed to the calling into existence of living matter and its maintenance in existence. On the other hand, we living things on this planet may be incredibly paltry in our importance and development as compared with the quite possible angels and archangels, the amazing manifestations of divine energy which may exist elsewhere in the universe.

Personally, I prefer to believe—since we are free to speculate, in the utter absence of definite knowledge—as did the late Winwood Reade, when he closed his wonderful essay on the Martyrdom of Man by the suggestion that Man was the grain of mustard-seed in the Gospel parable. Beginning ever so humbly on this tiny daughter of the sun, he may in future ages dominate the solar system.

We are also ignorant still as to the period in the Earth’s evolution in which living matter came into existence, probably through some simple chemical conjunction. We can dimly perceive that in the oldest rocks we have yet discovered, of the immeasurable Archaean period of the Earth’s history, there was no living matter; nothing, at any rate, organised enough, agglomerated sufficiently to be discernible. Directly we enter what is classified as the Primary Epoch we find ourselves, after one of those breaks in geological history that are as yet unbridged, in the presence of a great variety of living forms, of kinds quite within the conceptions we have based on the creatures we see around us at the present day.

The earliest fauna of Primary times is a marine fauna, that is to say, consists of creatures associated in modern times, at any rate, with a purely aquatic existence—corals, polyps, erinoids, crustaceans, shell-forming molluses and worms. Almost as early—perhaps, however, a little later than the invertebrates—appear vague types of fish which may be related to the modern lampreys, and, later, fish of peculiar armoured exterior, now no longer in existence, and fish belonging to the great Shark group with skeletons mainly cartilaginous and not bony.

The Shark sub-class of fishes played a very great part in the waters of the Primaries, and from them, quite conceivably, developed the Ganoids and Amphibians which were to lead up to the three great classes of Land Vertebrates.

In other words, in the early Sharks one sees a marked tendency to form the fore-limbs and hind-limbs from out of lateral flaps of skin, the four-legged arrangement of which we are the inheritors ourselves, though we choose to walk on our hind-legs and to use our fore-legs as the agents of the brain.

Also in the Primaries, though later than the Sharks, there arose the Ganoid fishes and that Amphibian class which is represented at the present day very humbly by the Frogs and Toads and Salamanders, but once, in Permian and Triassic times,* developed into crocodile-like creatures of considerable size—the Labyrinthodonts.

And, again, in the middle Primaries there grew out of these Amphibians true reptiles which had parted definitely with gills and had taken to breathing air solely through mouth and nostrils, and

Man's Place in the Universe

* The Permian period closed the Primary Epoch and was succeeded by the Triassic, which began the Secondary Epoch.
ANIMAL LIFE OF THE ARCTIC ZONE TO-DAY

The progress of life has been from North to South. Before the earth began its severe punishment of the recent Ice ages, the Northern Hemisphere, right up to the Pole, might have been—almost certainly was—a great centre of evolution (see p. 125)
The Distribution of Animal Life

oxygenating the body by means of the lungs. Before the Primaries closed, the principal developments of the Reptile group were sketched out, and were, in the course of the Secondaries, to expand further into Birds and Mammals.

But down to—at any rate the middle of—the Primaries we seem to be in the presence of a water world, of an earth without high mountains, covered mainly with water, mud-banks and sand-banks—water very shallow over wide areas, and, perhaps, deep in the great hollows as well as the Scorpions, Centipedes, and other Arthropods which had taken to a shore life, became more thoroughly addicted to breathing atmospheric air and to a life on emphatically dry land.

The inner energy of the earth, and perhaps the influence of sun and moon on its inner energy, thrust up the Archaean rocks in this new-made land, or the mud which overlay them hardened itself into what are now the Cambrian and Silurian formations in the geological series. Slowly the great con-

of the earth's surface. The Earth was then perhaps a slightly smaller planet in circumference than at the present day. We may imagine it thenceforth tending to shrinkage and some slight distortion of its spheroid.

In the course of this process the oceans were deepened, and the vast stretches of shallow water gave place to dry land, and the land wrinkled up into plateaus and mountain ranges. Probably from the beginning of the Secondaries the Fish became more thoroughly aquatic in their predilections than had been the case with their ancestral types. Some of these possibly led an almost amphibian existence (like some tropical fish do at the present day), and those Vertebrates tinentes were outlined and put together, and the distribution of land and water gradually assumed its present proportions.

But there were, and are still, fluctuations going on. Sometimes a Mediterranean Sea stretched slantingly across the northern tropics from the Gulf of Mexico to Central Asia and the Indian Ocean; while, in revenge, there were continuous land-connections between Europe and Asia and North America, between Africa and Brazil, Madagascar and India, India and Australia.

Possibly South America (at times divided into Andic and Brazilian sub-continents) was united by its southern extremity with Antarctica; and it may
CROCODILES AND WATERBIRDS

Before the wild life of the African lakes and rivers was scattered by the reckless gun of the pioneer tourist, it was possible to watch through field-glasses the close association of birds and crocodiles. Not only did the little spur-winged plovers actually pick from the interstices of the crocodiles' teeth small fragments of decaying fish and flesh, but they sought for and consumed the minute leeches which otherwise would infest the gums and palate of the crocodiles. The ferocious reptiles never harmed their little attendants, which warned them with shrill cries of the approach of the human enemy.
Ancient Land-connections

be, though not so probably, that Antarctica occasionally joined itself to Tasmania and Australia. New Zealand certainly was once connected through chains of now submerged or partially submerged islands with New Guinea and North Queensland. There may even have been a sufficient uprising of lands in the Pacific to permit of various lizards, snakes, and birds, fresh-water fish and crustaceans wandering from Asia into South America. Europe was ever and again directly linked with Africa across the Mediterranean.

Europe was sometimes much more cut off from Siberia than it is at the present day by a shallow sea uniting the Caspian with the Arctic Ocean.

India, Ceylon, and Indo-China were connected by a continuous land surface with all or nearly all the islands of the Malay Archipelago and consequently with Australia. The connection, however, between these two great regions—Tropical Asia and Australia and New Guinea—was interrupted in the later Tertiary, not enough perhaps to prevent the spread of early Man, or birds, bats and a few small land mammals, but enough to keep off the ubiquitous elephant, leopard, deer and pheasant.

On the other hand, the connection between North-East Asia and North-West America must have been substantially and frequently renewed, though it is broken at the present day by a narrow strait of water. Also at different times, but not so recently as the vanished Behring Isthmus, there was land connection between the eastern part of North America and Greenland, Greenland and Iceland, Iceland by an exceedingly narrow isthmus with the Faroe Islands, and consequently with Great Britain. At the same time, Spitzbergen was knit up with Norway and even may have joined Northern Greenland across the Arctic Ocean.

The New Siberian islands were a great outlying peninsula of Siberia, for they were actually inhabited down to perhaps

North America may even have known a form of Tiger before the ice ages, since the Tiger still inhabits Eastern Siberia and even penetrated to the New Siberian islands in the Arctic Ocean; less than 50,000 years ago by the tiger; and the tiger, we may be sure, did not come there with a view to Arctic explora-
The Distribution of Animal Life

oration, but to feed on a rich fauna of deer, bison, musk-ox, and mountain-sheep. North America, therefore, received its fauna of the Secondary and Tertiary Epochs from both Asia and Europe, and in the earlier Tertiaries to some slighter extent from North Africa and the Mediterranean Basin. This meant that in the later Secondaries, and perhaps also included Guiana. Venezuela may have been a link between the two.

Andine South America received its fauna and flora chiefly from Asia by way of western North America, with some contributions from Southern Asia across the Pacific. The Brazilian Island was peopled chiefly from the direction of Africa until the beginning of the human period, when large numbers of North American creatures, driven out of North America by various causes, found their way into all parts of the South American continent as far south as Tierra del Fuego.

India was an amazing breeding-ground for the evolution of life forms. Man himself may have struggled upwards out of the anthropoid within the limits of India, though it now seems more probable that this great event in the earth's history occurred in Western Asia or North-East Africa, or Eastern Europe.

Great Britain, in

as recently as the Mioene of the Tertiaries, there was land connection across the middle of the Atlantic which united North-West Africa and western Equatorial Africa with the West Indies, and, still more recently, with Guiana and Brazil.

From time to time South America was divided into two regions—one the nucleus of the Andine chain from Tierra del Fuego to Panama, and the other the great Brazilian Island, which perhaps those earlier days alternately a huge peninsula of Western Europe or a collection of mountainous islands, was another evolutionary area of importance. In fact, if the actual Hominidae or Man family arose in Asia or Eastern Europe, it would almost seem, from the recent discovery of *Eoanthropus*, that actual Man of the genus *Homo* was created in England if not in France.

Africa, but more especially Northern and North-Eastern Africa, was another
THE BLOTCHED GIRAFFE OF GERMAN EAST AFRICA
(Giraffa camelopardalis tippelskirchi)

Fossil remains of the Giraffe family are found from China, in the Far East, to Morocco in the Far West. This family seems to have attained its greatest developments and strangeness of evolution in North-west India, Persia, and Asia Minor.
The Distribution of Animal Life

The Tapir was probably evolved in Europe and spread thence through Asia into North America and into Central and South America.

The Saddle-back Tapir of Malaysia

The Tapir was probably evolved in Europe and spread thence through Asia into North America and into Central and South America.

Antelope sub-families; perhaps even the Oxen; several of the Rodent groups (such as the Porecupines and the other Octodonts); and several families of extinct Ungulates no longer represented by living forms. On the other hand, Tropical Asia would appear to have given birth to the Deer, to the Tragelaphs (the Eland-Kudu-Bushbuck group); and if not to the Oxen, at any rate to all the divergent groups of Oxen beyond the Buffalo stage; to the Bears, the Dogs, the Raccoons, perhaps to the Giraffes,* to the Capricorns, the Goats, and the Sheep, to the Peacocks and most of the developments of the Pheasant sub-family, to the Grouse, the Pigeons, the Cassowaries and the Moas.

* Fossil remains of the Giraffe family are found from China, in the Far East, to Morocco in the Far West. This family seems to have attained its greatest developments and degree of evolution in N.W. India, Persia, and Asia Minor. Its only living representatives are the Okapi and the Giraffe, solely confined to Tropical Africa at the present day.

The South American Jaguar

The American Jaguar is very nearly allied to the leopard and strongly resembles some of the Asiatic types in its markings. All the lynxes and cats of North and South America are of Asiatic origin and affinities...
Nature's Experiments

ing such slight evidence as we possess that the New World was always the "New World"; that most of the great experiments of the planet were made somewhere in Europe, Africa or Asia.

When they proved a success, their results invaded North and South America like modern lecturers and stage favourites. But North America was, at any rate, a good second to the Old World, as it is at the present day; and though it may not have originated the great ideas in our history, it has developed often to an amazing degree the notions it has received from Asia or Europe, or in South America from Africa.

Thus, when the land and water surfaces of the planet were roughly settled into two great divisions of continents and oceans, the Eastern and the Western Hemispheres, it was apparently in the Eastern Hemisphere that mammals and birds first grew out of reptiles. But the primitive bird quickly made its way to North America. Likewise those enormous reptiles of the extinct order of Ichthyosaurs, Plesiosaurs, Dinosaurs, and Pterosaurs apparently came into existence in Central Europe (Württemberg and Bavaria were regions of marvellous productiveness in the way of evolutionary growth) and spread thence to North America. Yet it was certainly in North America, so far as our researches go, that the Dinosaurs attained their tremendous and amazing proportions. Here also the flying reptiles or Pterosaurs attained their greatest dimensions, though they had British rivals very close in the running for monstrosity.

North America apparently gave birth to the Camels. It produced also the most amazing Ungulate forms of orders or sub-orders now completely extinct. It was probably likewise the birthplace of the Rhinoceros, possibly even of the

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THE TAILLESS LEMUR (Indris brevicaudatus)

It is permissible to consider that the Lemurs and the Bats originated concurrently in Eastern Asia, out of an insectivorous and generalised type of placental mammal, which had in its turn grown from a primitive marsupial like the Phalangers of Malaysia and Australasia.
Even when, owing to their modern distribution, we have felt inclined to attribute to certain groups of birds, like the Petrels and the Penguins, an origin in the Southern Hemisphere, some fresh discovery upsets this theory. (See p. 125)
The Atlantic Land-bridge

Giraffe family, whose nearest living ally seems to be the American Prongbuck.

The Tapir, on the other hand, was probably evolved in Europe and spread thence through Asia into North America and into Central and South America.

Bears, abundant as they are in the Americas, seem to be an Old World product. It is possible also that the true Cats—like the Civets, Hyenas, and Dogs—first came into existence in the Old World. Civets and Hyenas never spread to America—it is difficult to say why, since the Civet group is a very old one as carnivores go, and is well represented in Asia.

The Raccoons and Weasels were evolved in Asia and spread thence to America. The Hyenas, on the other hand, were peculiarly a European and African product and have played but a small part in the Asiatic fauna. Nevertheless it is difficult to explain why the Civet group—almost a parent group for all the modern carnivores except the Dogs and the Bears—did not reach North America. The Weasel family, allied in ancient origin to the primitive cats, to the bears and the raccoons, may also be of Old World origin though they have prospered exceedingly in the New World.

The Otter (see later) is an Old World creation, though its greatest modern development is in South America. The Lion was probably born in France from out of a large jaguar-like leopard; and the cave-dwelling Lion of the Pleistocene was an enormous animal nearly twice the size of the living lion. The Leopard itself seems to have originated in Europe, but in Asia to have taken on a form very like the Jaguar which it became when it entered America. The Jaguar once existed in North America as well as in South America, where it is of quite recent introduction.

The great Sabre-toothed cats (Machairodonts), almost a separate family in themselves because of their retention of primitive features in the skeleton, were evolved in Europe, whence they spread to Africa, to Asia, and western North America. When they entered South America they developed longer tusks and a greater size than they had acquired in the Old World.

The Porcupines were evolved in the Mediterranean Basin or North Africa, and probably spread through Asia to North America and into South America. But other sub-families of their section of the Rodent group must have proceeded direct from North-west Africa to Brazil and the rest of South America.

What we style the “American” or Platyrrhine* Monkeys were certainly originated in Africa, and intermediate types between them and the Lemurs penetrated into Madagascar. [Madagascar, though frequently separated from Africa and no longer in connection with the main continent since the Miocene period, has received all of its mammalian fauna from ancient Africa, except two or three species introduced by man during the last two thousand years.] These broad-nosed “American” monkeys (with an extra pair of premolars which the Old World monkeys have lost) crossed into Tropical America by the vanished Eocene and Miocene land-bridge across the Atlantic, and there they survive, having died out in Africa itself.

The Old World monkeys and baboons and early anthropoid apes also seem to have been evolved in the northern half of Africa and to have spread thence to Europe and Asia (as far east as Japan) but not to America.

* Platyrrhine means “broad-nosed,” in distinction from the narrow noses of the Old World monkeys. The Platyrrhine monkeys of America have had their greatest development in species and genera in Brazil, but they reached Patagonia in Miocene times, and there evolved types with big brain cases like little men! They never penetrated into North America.
The Distribution of Animal Life

The Antelopes (as distinct from the Tragelaphids) may quite possibly have had their origin from generalised bovine ruminants in France.

They developed a very extraordinary form (with enormous lower incisor teeth, like those of a beaver but twice as big) in the Balearic Islands after these became isolated from Spain. They peopled especially the eastern and southern shores of the Mediterranean, made Africa subsequently their great area of evolution, but in the first half of the human period reached India and Central Asia. They never, however, attained to America.

The Prongbuck, or so-called “ante-lope” of western North America, has nothing whatever to do with the real antelopes, but is a creature more nearly allied to the giraffe and to the primitive deer, and is no doubt of American origin from generalised ruminants akin to that “basic” group, the existing Tragulidae.

As to these interesting Tragulids or Chevrotains, whose living examples are restricted to Equatorial Africa and Southern Asia, they would appear to have been born in France, like so many other remarkable beasts and birds. Or if not in France, in the contiguous regions of the Rhine Valley. Apparently they are of very ancient origin and were derived from creatures of Eocene age, which had also reached and prospered in North America, where they gave rise to the Camels, to the Protoceratidae, and their comparatively degenerate descendant, the modern Prongbuck.

Though the Sheep and Goats were certainly born in Asia from out of the Capricorns (the Chamois-Mountain-goat group),* the Sheep penetrated in the Pliocene and Pleistocene into western North America, but did not get farther south than California and North Mexico. Numerous capricorns also reached Northwestern America from Asia, amongst others the ancestors of the Musk-ox and of the white Mountain-goat. Those creatures that were nearer allied to the Musk-ox de-

* The Capricorns are another “basic” group among the horned ruminants. They include the large Takin of Eastern Asia (Budorcas); the Musk-ox of Europe, Asia, and America (now restricted to Arctic Canada and Greenland); the Screeves of Sumatra, Japan, and the Eastern Himalaya; the Goralis of China (long tailed), and of India (short tailed); the white Mountain-goat of N.W. North America; the Chamois of Europe; and the Tahr (Hemitragus) of South India, North India, and East Arabia.
Dogs and Other Canines

THE HIMALAYAN Tahr, a TREE-CLIMBING GOAT

From the Capricorns, of which the Himalayan Tahr is a type, the Sheep and Goats were evolved in Asia.

veloped some extraordinary and very large forms in North America, some penetrating southwards into Mexico.

The Bison was born from some bovine like the Yak in Central Asia; but, though it rioted over the whole of Europe, it found a greater field of evolution in North America where it developed some monstrous types with huge horns. Bisons in the Pleistocene penetrated as far south as Nicaragua and as far west as England and Spain, but did not reach Ireland.

The Tiger was obviously an Asiatic creation, but apparently it spread within the human period into Arctic North America, where it perished in one of the Ice ages.

Another huge cat, strikingly like the lion, seems also to have reached North America at the same time. The Puma, like the Jaguar, is nearly allied to the Leopard, and certainly originated in Asia. All the lynxes and cats in North and South America are of Asiatic origin and affinities: but it is noteworthy that since the Glacial periods the cats proper and the ocelots have entirely left North for Central and South America.

The dogs, wolves, and quasi-jackals of the New World are likewise of Asiatic origin; but South America—Guiana and the Amazon basin—has a very remarkable living species of canine, the so-called Bush-dog (Speothos venaticus). This, though degenerate in the matter of teeth, has many primitive features about it.

Perhaps it found its way to South America from North America, as its nearest affinities would almost seem to be with the long extinct Temnoceyon of the Miocene formations of the central
THE GREATEST HEIGHTS AT WHICH ANIMALS ARE FOUND

This drawing is designed to show the vertical distribution of animal life; and the highest point at which the particular animal is found is shown in each case. In no way does the illustration indicate the range of the animal; indeed, the majority of those depicted are found down to sea-level, or nearly so; others, of course, are not: for instance, the yak is found at a height of nearly 19,000 feet, but seldom as low as 10,000 feet. The space between each pair of dotted lines, it will be noted, represents 3,000 feet. The small black horizontal lines mark the highest altitudes attained by the animals. The drawing is based on diagrams in Bartholomew’s “Atlas of Zoo-Geography.”
The Distribution of Animal Life

United States. The remarkable African Hunting-dog, which alone of all living canines preserves the vestiges of a collar-bone, was apparently born in Europe, and even once lived in England, but like so many other European mammals (no doubt owing to the glacial periods) found its way into Africa as its final home.

The remarkable African Hunting-dog, which alone of all living canines preserves the vestiges of a collar-bone, was apparently born in Europe, and even once lived in England, but like so many other European mammals (no doubt owing to the glacial periods) found its way into Africa as its final home.

Though the Reindeer has become almost an Arctic beast in recent times, its range once extended to Mediterranean Europe.

REINDEER

The Australian Dingo belongs to a type which is closely related to the ancestor of most of our breeds of domestic dog.

It may have been introduced into Australia by the agency of man, and be nothing but the original "wild dog" following early man from a West Asiatic home. Remains of a dingo-like dog have been found in Russia.

There are allied dogs living as wild or semi-domesticated beasts in New Guinea and all the large islands of the Malay Archipelago; but the nearest allies of the Dingo outside this region are not the Dhole dogs of Malaysia, India, and Central Asia, but the Chow type of Chinese domestic dog. This is evidently an animal very near in appearance to the vanished species of wild dog which early Man domesticated.

Such a type also originated the Eskimo dogs of North America, the Tibetan mastiffs, the domestic dogs of Rome and Neolithic Europe and North Africa. Other breeds of domestic dogs arose from the easy intermixture between the true dog, the wolf (of the various subspecies and species), and the jaekal. Not only do all these canine types freely breed together, but the offspring is in its turn vigorous and fertile.

Before the Glacial periods struck Europe a deadly blow (though they may have been the main cause that shaped true Man from a mere bungling anthropoid), these countries, and especially France, the Rhine Valley, and Northern Italy (possibly also Southern Britain) were great breeding-grounds of genera and species. I have already mentioned that in all probability the lion grew out of a large leopard in France, where we find his oldest remains, in point of geological history.

In addition to the other creatures already specified, ancient France seems to have been particularly rich in bird life. Here, apparently, were evolved the Flamingo, and perhaps even the early
France as Evolutionary Area

types of the Ostrich order, which wandered thence into Africa and from West Africa to South America, where they became the Rhea.

Again, ancient France may have seen the Trogons grow from out of primitive goatsuckers, the Hornbills specialize from birds more of the Hoopoe type, the Turacos from ancestral cuckoos, and the Parrots from out of the Turacos. Quite possibly she also saw the Pheasants evolve from some generalised gallinaceous group which in much earlier times had spread right across Asia into Australia (where it became the Brush Turkey family), the Pacific (the Megapodes) and South America (the Curassos).

These Curassos may quite conceivably have been born in France, have thence reached Africa, and have passed over the mid-Atlantic isthmus into Brazil. There seem to be no traces of them in the fossils of North America. It is an open question, however, whether in common with the Iguana lizards and a great many types of snake, spider, scorpion, etc., they did not reach Tropical America from Asia, along a string of islands almost bridging the Equatorial Pacific.

France certainly originated the Antelopes. Perhaps she also created the true Pigs.

She gave rise seemingly to the Guinea-fowl, which spread thence into Africa, and to the Francolins, which had the same history. The Guinea-fowl are nearly related in structure to the Turkey of North and of Central America, yet the Turkey has an evident relationship also with the Peafowl of Eastern Asia.

From which direction did the Turkey reach North America?

It seems almost too much of a strain on the imagination to think that it came there by the Arctic route from Britain via Iceland and Greenland. Yet it cannot have come from the West African Guinea-fowl across the mid-Atlantic isthmus, because no form of Turkey has ever been found in South America. On the whole, it seems
The Distribution of Animal Life

most probable that a generalised Guinea-fowl-type of gallinaceous bird originated in France and spread not only into Africa, but right across Asia (where it has left its traces in the beautiful Tragopan, which the plumage trade is striving its hardest to exterminate), and in some form nearly resembling the pea-fowl and the argus and peacock pheasants, penetrated through North-eastern Asia into North-western America, whence it reached the eastern States, Mexico and Honduras.

In eastern Central America its most amazing modern development still exists, the lovely jewelled ocellated Turkey, now brought near to extermination by the plumage hunters.

The Reindeer and the Moose or Elk are very isolated forms of Cervine, as to whose ancestry and origin we are still in doubt.

The most primitive type of elk, however, in point of antler, seems to have been found in North-eastern Asia, and the least peculiar reindeer in Northern Europe.

Though the reindeer has become almost an Arctic beast in recent times, it was once abundant in Mediterranean Europe. Here, probably, it grew out of a more primitive type of deer, and spread theenee into Northern Asia where it may further have generated the Elk. Both forms then made their way into North America.

The most generalised type of deer

HEAD OF THE CONGO HIPPOPOTAMUS

Africa, but more especially Northern and North-eastern Africa, was another first-class evolutionary area. Here (as far as we can guess from recent discoveries), or in contiguous lands of the Mediterranean, there arose the Hippopotamuses out of primitive pig-like types.
unsolved problems

Existing at the present day is the Musk-deer of Central and Eastern Asia, which has no antlers, but has developed its upper canines into long tusks. It retains some features in its anatomy which the other deer have lost. On the other hand, it has developed special peculiarities of its own, but its existence there and its absence from the New World would seem to show that the deer originated in Asia and spread thence to North and South America, as well as right across Europe, and from Europe into a small portion of North Africa.

Many thousands of years ago there were several other species of highly evolved deer in North Africa, but not the slightest trace, living or extinct, has ever been found of deer in Africa south of Tunis, Algeria and Morocco. No trace of deer, for example, has ever been found in Egypt except, of course, when introduced as a tamed animal from Syria. Yet there were fallow deer indigenous to Syria, and several other types of deer as well in Persia. No deer has ever been found in Arabia, a peninsula which is mixed in its affinities, containing as it does at the present day African, Asiatic, and European creatures. Similarly, no bear, so far as we know, ever entered Tropical Africa, though bears have only recently become extinct in Mauretania (a convenient term to express Morocco, Algeria, and Tunis).

It is amongst the unsolved problems in the distribution of animals why deer and bears should be completely absent from Tropical Africa.

At one time it was accounted for by supposing that Mauretania really formed a portion of Europe, and that it was cut off from the rest of Africa by a shallow sea which covered the greater part of the Sahara Desert. But this theory has long since been abolished by a proper examination of the Sahara Desert.

Small portions of this vast area have undoubtedly been shallow lakes down to quite recently. Still larger portions in Eocene, and perhaps early Miocene times, were connected with the Atlantic Ocean, so that a shallow sea ebbed and flowed over the northern basin of the Niger, perhaps as far east as Lake Chad, and as far south as the River Benue.

But for countless ages there has existed a permanent land connection between Tropical Africa and Mediterranean Africa in the shape of the great ridge of the Tibesti and Ahagar mountains and plateaus.

This ridge of high land connects Mauretania (in the south of Algeria) with Darfur; and along this ridge—even if portions of the low-lying Sahara were
marsh or lake—there travelled within the human period large numbers of remarkable beasts and birds generated in Europe, but seeking refuge from the Ice ages in Tropical Africa. It is difficult therefore to sever Mauretania from the past faunistic history of Africa.

North-east Africa—Egypt and the Northern Sudan—was, as I have pointed out, one of the world's remarkable evolutionary areas, especially in the first half of the Tertiary Epoch. Many of the creatures it generated spread during the Pliocene and Pleistocene periods up the Valley of the Nile into Tropical Africa. Others passed through Tripoli into Tunis, Algeria and Morocco. But Mauretania was also fed to a very marked extent by an important land-bridge persisting down to quite recent times between Italy, Sicily, Malta, and Tunis.

Malta is the minute vestige of a large island, and earlier still was a broad peninsula stretching south from Sicily. Like Southern Italy and Northern Africa it was peopled previously by various forms of elephant, hippopotamus, African rodent, deer, buffalo, tragelaph, antelope, equine, and carnivore. As it became cut off and diminished by the waters of the expanding Mediterranean, such of these creatures as did not promptly die gradually became dwarfed in size, till at last Malta became the home of extraordinary little elephants scarcely larger than pigs, pygmy hippopotamuses,* and so forth.

But Mauretania because of its permanent connection with Africa beyond, nourished an extraordinary series of large mammalia, most of which lasted on through the Pleistocene into well within the human period, and probably were only killed out by man himself. This fauna spread southwards all over Africa (except the dense forests of the equatorial belt), reaching even to the Cape of Good Hope.

In Mauretania there grew into existence the most amazing buffalo that the world has ever known (likewise found in South Africa)—a buffalo with horns more than fourteen feet long (the bony core of each horn was nearly that length, and the horny covering must have extended to a total of at least fifteen feet).

We do not only rely on fossilised or semi-fossilised bones for our belief in this creature, because it lived so recently that it was actually portrayed on the rocks by Neolithic Man, who did full justice to its enormous horns and huge size. Yet before it died out it actually seems to have been domesticated by some primitive Caucasian colonist of North Africa, for there are pictures of it with something like a pack-saddle on its back.

In North Africa within the human period also lived zebras, gnus, elands, nilghai (now confined to India), elephants of an Indian type as well as of an African, giraffes, bears, deer of several species (one with extraordinary antlers of many prongs), hippopotami and camels. There have long since ceased to be wild camels in Africa; perhaps the last of them lingered in Somaliland.

The domestic camel of the single-humped type apparently came into existence out of wild forms in Northern Arabia or Mesopotamia. The double-humped camel was once a native of all temperate Asia and Eastern Russia. The Camels, as already stated, originated in North America and spread thence into Asia, from which they extended their range to the Mediterranean basin. The Tragelaphs, on the other hand, (nilghai,
elands, bushbucks, etc.) seem to have originated in Asia and to have spread to western North America in the Pliocene, and at the same time to Syria and Greece, to Mauretania and the rest of Africa.

It is still a moot question as to where the true Horse of the genus Equus came into existence: whether in North America or in Europe or Asia.

Perhaps if we decide on an Asiatic answer to this problem we shall get nearest to the truth. But it may also be—though there exists scarcely a parallel to anything so remarkable in evolution—that the horse of the single-toed type was invented by Nature twice or thrice over.

Ungulate ancestors of the Horse, related to the parents of the Tapir and the Rhinoceros, were most abundant in Western Europe and in North America. In North America and in Europe the ancestry of the single-toed horse can be traced step by step. We begin with a creature possessing four toes on each foot with the vestige of a fifth, and about the size of a fox, with a very long tail and shallow molar teeth; and we end, both in Europe and in North America, with something equivalent to the modern horses, with much enlarged and strengthened middle toes and only slight traces of two other toes on either side, beasts of comparatively large size and with exceedingly long molar teeth.

WILD HORSES OF CENTRAL ASIA (Equus przewalskii)
The Ass sub-genus seems to have originated in Asia, and is still to be found wild in the above species. In Asia, likewise, the true Horse grew out of the Ass, and is still to be found wild in the above species. Perhaps if we decide on an Asiatic answer to this problem we shall get nearest to the truth. But it may also be—though there exists scarcely a parallel to anything so remarkable in evolution—that the horse of the single-toed type was invented by Nature twice or thrice over.

The Ass type seems to have originated in Asia—possibly West Asia—and not to have spread to North America. In Asia, likewise, the true Horse grew out of the Ass, and is still to be found wild as Equus przewalskii; but in Mediterranean Europe there grew out of an asinine ancestor—an ancestor no doubt very near to the extinct three-toed Hipparion—the Zebra, which, since it became really a zebra, was entirely confined in its range to the African continent, though it was found in Algeria (no doubt within the human period), perhaps also in Egypt.

In the singularly interesting collection
The Distribution of Animal Life

of early Greek models in terra-cotta in the British Museum may be seen two remarkable things in the way of evidence as to the acquaintance of the Greeks about 500 B.C. with beasts of Tropical Africa. One is the depicting not merely of zebras, but of something very like the Grévy zebra of Abyssinia; and the other is an extraordinarily good portrait of the Chimpanzi.

No doubt, both the zebra and the chimpanzi in times of the dynastic Egyptian rule, were found a good deal further north in their range than at the present day. The extinct North African zebra may still have been seen in Tripoli, or the Abyssinian zebra have extended down the Valley of the Nile to the frontiers of Egypt; while the chimpanzi perhaps still existed in the forests of Galaland. It is found to-day in the Bahrel-Ghazal and near the Albertine Nile.

The only suggestion of relationship with other groups which would hint at the evolutionary area of the Bats, is in South-east Asia and Malaysia, where there exists to this day an anomalous flying mammal known as Galeopithecus. This has some features which distinctly suggest affinities with the ancestors of the Bats, and others which imply resemblances to the Lemurs and to those remarkable arboreal insectivores of the Tupaiia genus found in the same regions.

The Tupaias—squirrel-like insectivores—though, of course, very much modified in the course of ages, probably give us a rough idea of the appearance of the type of mammal which began to branch off from the primitive generalised insectivorous stem in the direction not only of Man, but also of the Bat. We can imagine that this tree-dwelling pursuer of insects, with long-fingered, sensitive hands, a great power of leaping, and a loose skin, may have developed skin-flaps along the sides of the body and webs between the fingers which became in course of time the bat's wings. This process was arrested at a much earlier stage in Galeopithecus, wherein the hands remain comparatively small in size and not hugely disproportioned as they are in the Bats.

The kind of long-fingered hand which could in course of ages have been exaggerated into the extravagantly long fingers of the bats, may be described in that curious Madagascar Lemur, the Aye-aye. It is permissible, therefore, to imagine Eastern Asia as having been the centre from which originated concurrently out of an insectivorous and generalised type of placental mammal (which in its turn had grown from a primitive marsupial like the Phalangers of Malaysia and Australasia) the Lemurs and the Bats.

The lemurs spread thence to North America (but not to South America), to Madagascar, Africa and Europe, even to Southern England. They prospered and differentiated more especially in Mediterranean Europe, Africa and Madagascar; and in Africa (probably), as already mentioned, arose the American Monkeys, the true Monkeys and Apes from out of Lemuroid ancestors.

Reverting to the Bats, we may suppose that in Eastern or Southern Asia they early separated into two main lines of evolution. One followed the lemurine liking for fruit, and became the Fruit-eating Bats of to-day. These are confined in their range to Tropical Asia and Australasia and Tropical Africa; the other became the Insect-eating Bats which, in their pursuit of insects, and with their powers of long flight, colonised all the land-surfaces of the world that lay within the tropical and temperate zones, where there were insects in sufficient abundance for their sustenance.

The most primitive and least specialised form of bat probably is to be found in New Zealand at the present day. At any rate, if it be not altogether primitive, it is a bat which flies comparatively
Archaic Types

little and crawls about the limbs of trees in the search for insects.

The Insect-eating Bats—but not the Fruit-eating sub-order—reached North and South America, perhaps by two different routes: the ancient Behring Isthmus and the Pacific archipelagoes.

The bats of South America are more closely related to those of East Asia and Oceania, and here was developed one of the most extreme forms, the Vampire Bat. This no longer cares for insects; it lives on the blood of other mammals.

Taken as a whole, it may be said that South and East Asia and Australasia have developed the most varied and remarkable forms of bat of both the sub-orders, the Fruit-eating and the Insect-eating. The bat, however, is a very old type and can be traced far back into Eocene times.

The origin of the Rodents is even more remote. It is possible they may have been developed from the insectivores in North America or North-west Europe. The most recognisable stage in the evolution of rodents from generalised mammals which had a complete dentition of incisors, canines, premolars and molars, were the Tilodonts of North America. Some of these grew to quite a large size, rather bigger than the modern capybara; but in much more recent times true rodents had extravagant developments in both North and South America and in the West Indies, where some of them became as large as bears and hippopotamuses.

A gigantic Beaver was developed in Britain and France, and a similar form probably in North America. Africa must also have been a great evolutionary area of the rodents, and the principal South American forms—those which are known as the Octodonts—seem to have come from Africa originally, where two or three Octodont genera remain.

The Squirrels, which on the whole are the most generalised of living rodents as regards their teeth and skull form, seem to have had Eastern Asia as their first home. There they are to be found at the present day in their largest, strangest, and most beautiful types, either as tree squirrels—gorgeously coloured—or flying squirrels. But from Eastern Asia they made their way into North America, though scarcely thence into South America, a continent almost without squirrels, except in Guiana and Northern Brazil. Here, once again, there is a curious correspondence as regards fauna between North-eastern South America and West Africa, from which one or more genera of small squirrels have passed over to Equatorial South America. From out of the Squirrels grew the Marmots in temperate Eurasia, whence they penetrated into North—but not into South—America. There are no members of the squirrel family in either Australia or Madagascar. Both regions are without any other form of rodent than certain mice and rats.

When we come to glance at the origin of the Marsupials and of those still more archaic creatures the Egg-laying Mammals or Monotremes, we go so far back in time that the modern distribution of land and water seems to have little application.

The Egg-laying Mammals—reduced now to two genera in distinct families or orders—the Duckbill or Platypus of Australia and Tasmania, and the Echidnas of Australia and New Guinea—have as their nearest relations in the very distant past, in the Secondary Epoch, small mammals which lived in Britain and in North America, perhaps also in South Africa. Indeed, it is very probable that the mammalia originated from reptilian ancestors in Africa and spread thence through Europe to North America and through Asia to Australia.

The Marsupials possibly came into existence first in Europe and North
The Distribution of Animal Life

America. So far there is not the slightest trace of them to be found in the geological strata of Africa or of Southern Asia, yet they must have ranged at one time all through temperate Eurasia from England in the west to, perhaps, Japan in the east, and thence into North America,* where they developed chiefly the Opossum type.

This type in course of time passed through Central America into South America, where it has branched out since Pliocene times into a number of species. But at an early date the Marsupials had become subdivided into two main groups:

those which like the Opossum and Thylacine had teeth of the generalised and primitive mammalian type and arrangement—inisors, canines, premolars and molars — and those which like the Phalanger and Kangaroo went in for the development of great rodent-like incisors and huge premolars, especially in the lower jaw, and

regarded their canines as a negligible quantity.

At the present day the

* It is perhaps more probable the Didelphine or Opossum-like Marsupials ranged right across "Atlantis" or the Euramerican continent of the early Eocene, of which Britain was the easternmost projection.
The Diprotodonts

distribution of these Diprotodonts, as they are called, is very remarkable. They are found in abundance in New Guinea, Australia and Tasmania, but elsewhere only in Andine South America, between Ecuador and Chile. On the other hand, in southern South America there exist fossil remains showing perhaps several other primitive Diprotodonts and a variety of Polyprotodonts; these last display obvious affinities with those of Australia and especially of Tasmania.

Until recently, a way much favoured for accounting for this curious distribution lay in connecting South America with Antarctica before the Ice ages of the latter Pliocene; and, again, Antarctica with Australia by way of Tasmania. But the most recent researches in Antarctica and in sea-soundings in the Southern Hemisphere rather discredit this theory.

Obviously, South America was connected with Antarctica down to a comparatively late period. It is very questionable, however, whether there was continuous land communication, coupled with a genial climate, between Antarctica and Tasmania within the age in which mammals developed.

If there was such a connection, its results should have applied more strongly to New Zealand; but in New Zealand no traces whatever have been discovered of marsupials or any indigenous mammals, except bats and recently imported rats. We are, therefore, almost brought back to the older guess that both Polyprotodont and Diprotodont marsupials developed in the Northern Hemisphere, in the region once common (through Northern Atlantis) to Europe, North America and Asia; and that in the course of ages a few examples penetrated down the western half of North and South America on the one hand, and through Eastern Asia and Malaysia to Australia on the other. At the present day, as regards Eastern Asia, marsupials in the form of phalangers are found as far northwards as the great Malay islands of Timor, Flores, and Celebes.

Within the limits of the Australian island-continent, marsupials had no rivals until the age of Man. There, consequently, they rioted in development, and some of them grew to the size of a rhinoceros.

These huge marsupials only died out from fifty to a hundred thousand years ago, when conditions of great aridity began to afflict all the central part of the Australian continent.

So far I have dealt almost entirely with one small section of the Vertebrates in my discussion on the ancient distribution of life forms; but that is because, when we go back beyond the periods in which mammals existed, the relations of land and water appear to have been so different to what they are at the present
The Distribution of Animal Life

day that they have little or no bearing on the modern aspects of zoography.

But we do not only rely on mammals and on birds that are not of long flight in dividing up the earth’s land surface at the present day into distinct zoographical regions: we also decide these on the distribution of land-crustacea such as the Land Crabs and Crayfish, on the distribution of Spiders and Scorpions, of Beetles and Bugs; of Fresh-water Fish, Frogs, Salamanders, and the limbless Amphibians; on similar limbless Reptiles (the *Amphisbaenidae*); on the location of the Crocodiles and Alligators, Tortoises and Terrapins, Lizards and Chameleons, Cobras and Vipers; on that of the Struthious birds, the Petrels, the Hawks and Vultures, the Kingfishers and Trogons, and virtually every other order of birds, except it be those with such a passion for migration that areas of vast ocean are no barrier, while climate is a matter of indifference.

At the present day, though there is still a nibbling and a quibbling on the part of the fastidious—and ever and again these quibbles are justified by fresh discoveries—the land areas of the world’s surface are divided into the following distinct zoographical divisions. There is (1) the Holaretic, a great belt round the world which includes Europe, Asia, north of the North Tropic, North Africa, Canada, Alaska and much of eastern North America. (2) The Sonoran region, all that part of west and south-west North America which has a somewhat peculiar fauna of its own, especially such remarkable survivals as the Prong-buck and the Sewelles. [The Sewelles (*Haplodon*) are a group of Rodents distantly allied to squirrels, and perhaps presenting slightly more generalised features in their anatomy than the squirrels or any other rodent groups. They are restricted in their range at the present day to British Columbia, Oregon, and California]. (3) Tropical Africa, or all Africa south of the Northern Tropic (23½° N. latitude). (4) Madagascar, including some of the adjacent islands or islets. (5) Tropical Asia, including all Malaysia north of “Wallace’s Line.” (6) Tropical America, including all the West India islands and Central America. (7) Australasia (New Guinea and the eastern Malay Islands, Australia, and Tasmania), and (8) Oceania, i.e. New Zealand and all the Pacific archipelagoes not adjacent to New Guinea. This last region, which is sometimes called Polynesia, is mainly distinguished by what it has not got, namely, the almost complete absence of indigenous mammals (except bats). But there are certain puzzling affinities between it and South America, especially in regard to its birds and lizards, as there are also between New Guinea, Australia, and South America.

A survey of all forms of animal life, coupled with the distribution of plants, tempts one to the conclusion—almost a certainty as regards the far past down to the middle of the Secondary Epoch—that the world’s land surface has been divided into two main areas of evolution, a northern zone and a southern zone. These two radiations of living forms meet more or less in the region of the Equator.

Yet, though this is undoubtedly the ease in the Primaries and early Secondarys, it seems more probable that about the middle of the Secondary Epoch a great preponderance of land and of

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* The great traveller and exponent of zoology, Alfred Russell Wallace, in explorations of the Malay Archipelago in the middle of the nineteenth century, showed that a zoographical line of demarcation passed between the Islands of Bali and Lombok, between Celebes and Buru and Jilolo. West and north of this line, the fauna was that of Tropical Asia; east and south, of Australasia. On the whole, his demarcation has been adhered to, though it is realised that a few Australasian beasts, birds, and reptiles are found in the more easterly Malay islands, while a few mammals and birds cross over from Asiatic Malaysia into Australasia.
Differentiation of Species

genial climate lay in favour of the Northern Hemisphere. Here there was aggregated nine-tenths of the land surface of the globe, in contrast with the Southern Hemisphere, which mainly consisted of ocean.

The progress of life was from north to south, and this was accentuated when the Ice ages began (or recurred) towards the close of the Pliocene. The Miocene, and no doubt much of the Eocene and as I have said, the advance of species was preponderatingly from north to south.

Even when, owing to their modern distribution, we have felt inclined to attribute to certain groups of birds, like the Petrels and the Penguins, an origin in the Southern Hemisphere, some fresh discovery upsets this theory. Such faint indications of relationship as the penguins offer are to extinct and existing

The TuaTera

This large lizard-like creature of New Zealand is the representative of a primitive order of reptiles that flourished as far back as the Primary Epoch, and once inhabited most parts of the Old World

The preceding Cretaceous periods, had been ages of genial and somewhat uniform climate. Before the earth began its severe punishment of the recent Ice ages the Northern Hemisphere right up to the Pole might have been—almost certainly was—a great centre of evolution.

On the whole, however, we find that then, as now, the greater energy in the differentiation of life forms seems to have taken place in the regions which still possess the best climates—Central and Southern Europe, Northern Africa, Western Asia, subtropical North America, Brazil, and Argentina. But, groups of birds in the Northern Hemisphere, and the range of the penguins, it must be remembered, stretches as far north at the present day as the Galapagos Archipelago under the Equator. As to the petrels, fossil albatrosses have been discovered in the Pliocene strata of England; and though the biggest of the albatrosses is restricted to the Southern Hemisphere, its near relations range as far north as the coasts of Oregon or of the North Faeroe Islands.

North Africa is rightly placed within the Holartic division at the present day, because the preponderating relationships
The Distribution of Animal Life

of its fauna and flora are with those of Mediterranean Europe. Yet not many thousands of years ago it was a debatable region, almost as much tropical African in its affinities as European. Together with Southern Italy, Southern Spain, Greece, Syria and much of Persia, it constitutes the Mediterranean subdivision of the Holarctic, and to a certain extent it has affinities in fauna and flora which reach right across Asia to the Pacific shores.

There is even a remarkable resemblance between certain species of birds inhabiting Spain, Japan, and Formosa!

Southern China, properly speaking, lies within the Oriental or tropical Asian division. Formosa is one of those debatable grounds, partly Oriental, partly Holarctic. Japan, even, has a dash of the Oriental in its fauna.

There are also Sonoran affinities in China. One of these is connected with the distribution of the Alligator. The alligator genus of the Crocodile order is restricted in its present range to Florida and Texas on the one hand, and to the rivers of Eastern China on the other. The true Crocodiles, of the genus Crocodylus, have a peculiar distribution at the present day. They are found just within the southern limits of North America (perhaps in Southern Florida) and in the rivers of eastern Central America and of the larger West India islands; also in northern South America, in the basin of the Orinoco. Otherwise, the true Crocodile puts in no appearance in America. It is found in the northern and tropic parts of Australia and there develops one or more peculiar genera.

There are very peculiar crocodiles in Borneo in addition to the ordinary genus, and these have some affinity with peculiar crocodiles in West Africa. There is no true Crocodile in the greater part of Central America or South America. The creatures which seem to be crocodiles are the Caimans, more nearly related to the Alligator. But, lest any one of these outlying regions should be vain and exclusive on account of its peculiarity of crocodilian forms, these eccentricities of distribution are explained when one examines the strata all over the world. It is then obvious that what are now regarded as peculiar Bornean, West African, American, or Chinese genera in crocodiles, were once inhabitants of Southern England, of France, the Rhine Valley, Italy and North Africa.

New Zealand possesses one most remarkable living form which should have been adopted as its national emblem, instead of having been persecuted till it is on the verge of extinction. This is a large lizard-like creature, known as the Tuatera. It is the representative of a primitive order of reptiles that flourished as far back as the Primary Epoch and once inhabited Scotland, England, Germany, India, and no doubt most parts of the Old World. Its last relic penetrated as far southwards as New Zealand, and of late has been almost exterminated in that country owing to the heedlessness of its vigorous White colonists, who have only begun, within the last few years, to take any interest in the zoology of their magnificent country.

New Zealand, although it lies within the temperate zone of the Southern Hemisphere, is really a portion of the Northern Hemisphere in its affinities of fauna, if not of flora. It possessed, down to a few hundred years ago, probably the most gigantic birds that have ever lived, unless the extinct gigantic bird of Madagascar was even bigger. These belonged to several different families and are generally known as Moas. But they came from the north, and no doubt once existed in New Guinea and North Queensland likewise, where their nearest relations, the Cassowaries, are found at the present day. But there are fossil forms in India suggesting an affinity with the
EXTINCT, OR ALMOST EXTINCT, BIRDS

The specimens here illustrated, of New Zealand and other extinct and rare birds, are in Mr. Walter Rothschild’s unrivalled collection at Tring. New Zealand possessed, down to a few hundred years ago, probably the most gigantic birds that have ever lived. These belonged to several different families and are generally known as Moas.
The Distribution of Animal Life

New Zealand Moa, and even in England and France. There are clear indications that New Zealand is the surviving fragment of a great semielire of land which stretched out across the Pacific from New Zealand to North Queensland and connected the Australian continent with New Guinea. New Caledonia, which came very near to this enormous peninsula, is the vestige of another large Pacific island of great antiquity. It possesses the very peculiar land bird, the Kagu, a primitive crane.

The distribution of the mammals which live wholly in the water, like Whales, Mammals that Live in Water, Seals, Sea-lions, etc., is interesting, and as yet a problem not wholly solved by fossil evidence.

The Whale order obviously originated in the region of Egypt; as those aquatic early ungulates, the Sireniens, did likewise. The Sireniens (Manati, Dugong, etc.) found their way in the course of time along the coasts of the Mediterranean to the Atlantic. They penetrated by the Eocene and Miocene seas into the very heart of Africa, up the Niger and the Benue Rivers to the vicinity of Lake Chad. They coasted—they could never be other than coasters, since they lived entirely on the vegetable growth of rivers, estuaries and sea coasts—along the vanished land-bridge that connected West Africa with Brazil and the West Indies. Here they have left their traces at the present day in the Manati, which, in two different forms, inhabits Florida, the West Indian Islands, and the north-eastern South American rivers, as well as the rivers of West Africa.

Another type passed out from the Mediterranean into the Red Sea when Africa was an island, and became the Dugong, which at the present day inhabits the shores of the Indian Ocean and the Western Pacific within the tropics.

The Dugong, in fact, ranges from the Red Sea and the Zanzibar coast right across to New Guinea and Fiji. But another type crept northwards around China till it had reached Kamschatka and Behring’s Sea. Here it grew to an enormous size, and here it was found and destroyed because of its helplessness and its excellent meat, by the Russian pioneers who explored and colonised North-eastern Siberia. This was the Rhytina.

The Whales, who also originated in the Eastern Mediterranean from large, long-headed carnivorous Creodonts, soon gave up the land altogether for a completely aquatic existence, and roamed in the deep oceans as well as in the shallower seas. At first, no doubt, they thought of nothing but fish, which is the sole diet of some of their toothed descendants. But then they took, as some of the seals are doing now, to the eating of shell-fish, cuttle-fish, and of those swarms, those millions of tiny molluscs and crustacea with which even the northern and southern seas are full.

Amongst many sub-orders and families of the differentiated whales, therefore, teeth were no longer a necessity. Here and there an eccentric tusk was developed, as in the case of the Narwhal, or the equally strange-looking Mesoplodon. But instead of teeth and for the better strain ing of the heterogeneous substances they went at open-mouthed, they developed ridges of their soft palate into whalebone, which acted as a sieve.

The whalebone whales were obviously evolved first in the northern seas, and until quite recently were thought to be confined to the Northern Hemisphere in their present range. But a very interesting small type of whalebone whale (Neobalena) within the last thirty or forty years has been revealed in the waters of the Southern Hemisphere, only in the vicinity of South Australia and New Zealand.

Porpoises of all kinds frequent all the oceans, but some Porpoises or Dolphins,
Platanistidae Sotalia and the family, have also reverted to the life of their remote Eocene ancestors and have come to frequent rivers only, to live in fresh water and feed on the fish, perhaps also to some extent on the water-weed of tropical rivers. There are fresh-water dolphins in the Ganges, in the Yangtse-Kiang, in the Cameroons River of West Equatorial Africa, and up the Amazon almost to within sight of the Andes.

The Seals are divided into three principal groups, (1) the true Seals, (2) the Walruses, and—very distinct from the foregoing—(3) the Sea-lions or Eared-seals.

So different in many points of anatomy are sub-orders (1) and (2) from (3), that it has been sometimes questioned whether the Sea-lions were of separate origin from the Seals and perhaps derived from the primitive bears. At any rate, all three have grown out of land carnivores that have taken to an existence first in rivers, and, later on, in the open sea.

There are some suggestions that seals, sea-lions, and walruses all came into existence in North America in the Eocene period, perhaps even in northern North America, within the Arctic zone.

The Sea-lions preferred the warmer seas and found their way along the Pacific coast of North America to that of South America. They then crossed over the Southern Pacific and established themselves, where they are now to be found, on the south coast of Australia and of New Zealand; and also passed round South America across the southern Atlantic to the coasts of southernmost Africa. They have never penetrated, so far as we know, up the Atlantic coast of South America, nor the Atlantic coast of Africa or Europe; nor are they met with in the Indian Ocean away from the vicinity of Southern Australia.

The Walruses specialising, we may suppose, in the Arctic seas north of America, passed on the one hand into the Northern Pacific, where their finest examples may be seen at the present day between Alaska and Siberia, and round Greenland and Iceland to the seas of Northern Europe. Their southernmost range seems to have been the coasts of Suffolk, Kent, and Belgium, where they existed well within the human period.

The true Seals, on the other hand, became almost world-wide in distribution,
The Distribution of Animal Life

though as regards number and variety of species they preponderate in the Northern Hemisphere. They are, however, found in all the oceans, but are more or less, at the present day, divided into two main groups: those of the northern seas, and those which extend in their range from the Mediterranean and Gulf of Mexico southwards to the Antarctic.

On the west coast of North America the true Seals evolved a type extraordinary and remarkable in appearance—the Sea Elephant. This has a very much separated distribution at the present day. One of its species, the best known, is found off the coast of South California (and has only recently been exterminated from the Pacific coast of Central America), and the other is met with far away in the Southern Hemisphere, off the coasts of Tierra del Fuego, the Falkland Islands, South Georgia, and the Kerguelen and Heard archipelagoes in the southernmost parts of the Indian Ocean.

The distribution of Otters has its features of peculiar interest. Otters living in fresh water are of nearly worldwide distribution, except that they are quite absent from Australia, New Guinea and the eastern Malay Islands. They reach their biggest development in size in eastern South America.

But the Sea Otter has much superficial resemblance to a seal, though it is impossible to derive one from the other owing to their fundamental differences in teeth. The Sea Otter is confined to the northeastern and northwestern waters of the Pacific Ocean, to the coasts of Kamtschatka and of Alaska and British Columbia. It is now nearly extinct, owing to the value of its fur.

The distribution of the Bears has its inexplicable gaps. The Bears probably originated, like the Raccoons, from something dog-like carnivores in Central Asia. A rather small and primitive type of bear has found its way down the Malay Peninsula to Borneo and Java.

India is rich in bear types. It has in the Himalayas a form similar to the Malay bear; but also the extraordinary Sloth Bear (Melursus), with loose, prehensile lower lip and extravagant development of hair. In the Himalaya Mountains there are Black bear and Brown bear, and across the borders of Tibet the rare and beautiful Greyish-Blue bear (Ursus pruinosus).

The Brown bear, with the closely allied Grizzly Bear and the Chocolate-coloured bears of Alaska and North-east Asia, has ranged over all temperate Europe and Asia into North America. But although a form of the Brown bear has penetrated into Syria and Palestine, it has never entered Tropical Africa. Yet in all probability there were two or more types of bear in Mauretania, one of which may have lingered on to the nineteenth century, though it would seem to be quite extinct now (there is some evidence that the last surviving bear of Morocco had black fur).

Bears of a true Ursine type, as well as of a much more generalised form, also penetrated from North America into South America. The Spectacled Bear still exists in the high mountains of the Andes range, but the monstrous form known as Arctotherium, of which abundant remains are found in the Argentine, must have died out some thousands of years ago.

In the Arctic regions or in one of the Glacial ages the Polar Bear grew, no doubt, out of some brown-coated ancestor. He probably originated in Northern Europe, and thence came over on the land, or on the ice-floes, to Northern Asia and North America and Greenland.

The most gigantic bears at the present day are found in Alaska. There are sometimes peculiar species living isolated
on comparatively small islands. Huge as they are, however, they are probably less in bulk than the extinct Cave Bear of Europe and Western Asia.

This beast must have been a terrifying monster for early Man to battle with. It had lost nearly all its premolar teeth, and had even neglected its molars, in order to develop big and broad canine teeth, with which no doubt it tore out huge chunks of flesh from its victims and swallowed them without much mastication. In all probability the Cave Bear, like the Cave Lion of prehistoric Europe, reached its greatest size in Southern Germany.

Although the Lion existed within historical times in the Balkan Peninsula, and within the Neolithic period in Italy, perhaps in Spain, and certainly in Southern Germany, it was confined at the opening of the nineteenth century to most parts of Tropical Africa, Western and Southern India, Persia and Mesopotamia. More than 2,000 years ago it still inhabited Syria and Palestine, and no doubt Upper Egypt. It was killed out in Tripoli as late as the seventeenth century. But when the French invaded Algeria in 1830 they found that lions swarmed in Algeria and Western Tunis, and they also existed over a great deal of Morocco.

The writer of these lines has actually seen and assisted in the killing of lions in Eastern Algeria and Western Tunis in the year 1880, but from that time onwards the lion was rapidly extinguished under the attacks of sportsmen and well-armed natives, so that at the present day it is doubtful whether a single wild lion exists anywhere between Morocco and Tunis.

To find wild lions in this direction southward from the Mediterranean—one would have to go right across the Sahara till one reached the native state of Air at no great distance from the Niger basin.

In India the Lion was rapidly killed out by the British, so that it is now reduced to a few hundred in number, which are carefully preserved in the country of Kathiawar in Western India. It is almost extinct in Southern Persia, and has long since vanished from the central or northern parts of that kingdom. A few lions still remain in the marshes that border the Euphrates.

In Africa the Lion is found in the Egyptian Sudan, in the south of Abyssinia, in Somaliland, and all through East Africa and the Great Lake region down to the Zambezi. Across the Zambezi there are a few lions left in Portuguese East Africa and Southern Rhodesia. In West Africa the lion inhabits the southern and south-western parts of the Congo basin, and also some parts of Angola. It is found in the innermost regions of the Cameroons to the verge of the Congo basin, in Northern Nigeria, in French Nigeria, and in Senegal.

The range of the Tiger is purely Asiatic. It is found in rather a small form in North-east Persia, in the coast-lands of the Caspian. It also inhabits sparsely parts of Afghanistan and West-central Asia. Its range extends over the whole of India from the Himalayas to Cape Comorin, but it has never penetrated to Ceylon. It is met with occasionally in Burma, in the Malay Archipelago, Sumatra, and Java, but not in Borneo. It is still found in Indo-China and the southern provinces of China proper, but it attains its most magnificent development in the far north of China, in Manchuria, and then extends still into Eastern Siberia.

The Leopard is found over the tropical and sub-tropical regions of the Old World, but nowhere within the limits of Europe. It still inhabits parts of southern Asia Minor, Persia, and the Sinai Peninsula, in a sub-species quite distinct from the other leopards of
The Distribution of Animal Life

Africa and Asia. In North Africa there is a variety of large size inhabiting Tunis, Algeria, and Morocco.

In Tropical Africa, the leopard has four distinct forms. There is the leopard of the Ruwenzori range of mountains, which has large spots rather like those of the jaguar. There is the ordinary forest leopard of all West and West-central Africa, which is scarcely distinguishable from the leopard of India; and there is the leopard of East and South Africa which has profuse and small rosettes.

Somaliland possesses a rather dwarf type of leopard, as well as the big form; There is a leopard in Manchuria and Eastern China which is somewhat similar to the Persian type. The Indian leopard, which, as I have said, is very like that of forested West Africa and is the commonest type of leopard in menageries (very often in a black form), extends from the Himalayas to Ceylon and right through Malaysia and Indo-China to Java. There is probably no leopard in Borneo, though on this point there are conflicting statements.

In Central Asia and the northern Himalayas there exists the beautiful Snow Leopard, quite a distinct species by itself. The American Jaguar, which is very nearly allied to the leopard and resembles very strongly some of the Asiatic types in its markings, once, no doubt, ranged all through the western parts of North America into the south-eastern States. But, from the eighteenth century onwards, at any rate, it has not been found farther north than Texas, though undoubtedly it existed at no great distance of time in Alabama and perhaps in Florida and Georgia. It is found, more or less abundantly, all through Central America and all over South America except on the Andes mountains, its southernmost range extending into Patagonia.

The Puma, which is nearly allied to the true leopard, ranges at the present day from the central and east-central portions of the United States and from parts of California into nearly all Central and South America north of Tierra del Fuego.

The island of Borneo, though it belongs to the Oriental division, is not at all
Fauna of Borneo

easy to account for in zoography, and in relation with the past arrangements of land and water.

Borneo possesses the Asiatic elephant, but this may have been introduced by man. It also has a Malay form of rhinoceros, and it has the Asiatic buffalo. But there is no tiger, and the existence of the leopard, though often asserted, remains unattested. On the other hand, it has a leopard-like cat of great beauty, peculiar both for its markings and in the length of its canine teeth. This is the Clouded Tiger. It scarcely, however, attains in size to the average leopard. Its range, besides Borneo, includes Sumatra, Java, Malay Peninsula, Indo-China and Formosa.

Borneo has many peculiar rodents occasionally suggestive of those that have penetrated to Australia. It has a few monkeys of the Macaque and Semnopithecus genera, and shares with Sumatra the Orang-utan, one of the three surviving genera of big anthropoid apes. There is also to be found in Borneo at least one species of the smaller anthropoids, the Wahwah Gibbon.

It has no typical pheasants (Phasianus) and no peacocks, but some amazingly beautiful gallinaceous birds of other genera, such as Acomus, Lophophasis, Lophura (the "Firebacks"), the Argus, and the Peacock-Pheasant.

The distribution of the Anthropoid Apes at the present day is by no means uniform. They are, of course, limited entirely to the Old World and almost exclusively to the tropics.

The Chimpanzi has the widest range in Africa. It is found from Senegambia in the west, through most of the forested regions near the coast to the Bahr-al-Ghazal in the Valley of the Nile and the countries of Nyoro and Toro between Lake Victoria and Lake Albert in Central Africa. Southwards its range extends to Lake Mweru, and south-westwards, perhaps, to Northern Angola, though it is still very uncertain whether the Chimpanzi or any Anthropoid Ape is found to the west and north of the main Congo River.

The range of the Gorilla is right across Equatorial Africa from the south-west frontier of Uganda and North Tanganyika to the Cameroons coast. It is not found anywhere to the west of the Congo-Lualaba, or south of the Congo main-stream. In Asia the Gibbons are met with in the south-eastern Himalayas (Assam), in Indo-China, the Island of Hainan, and Southern China; also in the islands of Borneo, Java, and Sumatra. In Sumatra and Java is further found a large form of Gibbon known as the Siaman.

The Orang-utan was formerly found in several sub-species or varieties in the southern part of the Malay Peninsula, but nowadays only in the islands of Sumatra and Borneo, and not in Java.

H.H.J.
7. The Distribution of Man


THROUGH the extraordinarily rapid progress now being made in regard to palæontological and archæological discovery, we are constantly shifting (within a certain area) our theories as to the place of Man's origin on earth. Did he rise up from the anthropoid ape in Tropical Asia, in Syria, in Egypt, in the Rhine lands, Asia Minor, the Balkan Peninsula, France, or even Southern England?

In the middle of the nineteenth century those who dared to speculate on the subject at all, other than along prescribed and not proscribed theories, would have perhaps guessed at the Rhineland as the region of Man's birth. They would have been impressed by the discovery of the Neanderthal skull, and, not knowing all that we now know about Neanderthal Man, they would have said: "This is the nearest to the ape that we have found in regard to ancient Man, and here probably was the region in which the anthropoid was perfected into the hominid. Here our ancestors became human by the development of a large brain, even if they retained the prominent brow-ridges, the shuffling legs, the inelegant spine, the short neck, and the reeding chin of the ape." But within the last two or three years we have realised that Neanderthal Man was an offshoot, a grotesque variant of early humanity, a separate species which died out about 30,000 years ago.

Since 1856 several amazing discoveries have been made, wrenching our theories in this direction and in that. In 1892 were discovered in the cliff of a river valley of Java, almost under the Equator, the cranium, the teeth, and the thighbones of a creature which was neither perfected Man nor anthropoid ape, but almost midway between; the Missing Link, in fact, called by its discoverer, Pithecanthropos erectus, or "the ape-man which walked upright." Its brain in size was just midway between the lowest human and the highest anthropoid average. Its teeth were more human than simian, and, whether or not it was bowed at the knee, it certainly had an upright posture and walked easily on its hind legs.

But was Java therefore the region of the human origin? May this not more
AKIN TO THE APE: THE EARLIEST KNOWN INHABITANT OF ENGLAND—THE MAN OF SUSSEX (*Eoanthropus Dawsoni*)

The man—or more likely woman—whose remains were discovered at Piltdown, in south-central Sussex, in 1912 and 1913, was undoubtedly akin to our ape ancestor. The cranium was indubitably human; but the lower jaw was ape-like in the absence of a chin and of the "genial tubercles," which denote the attachment of the tongue muscles controlling speech; but most of all in the presence of a projecting, pointed canine tooth.
The Distribution of Man

probably have occurred in India, where we know there were anthropoid apes once existing that seem to have been the common stock from which the Gorilla, Chimpanzei, and Orang-utan were de-

propagate new species, genera and families. From this centre of radiation stray intermediate types might well have migrated as far to the south-east as Java or to the north-west or north as Sussex or Central Germany.

But we also know that anthropoid apes existed in France and in South-East Europe; and lastly, to add to the intricacy of the puzzle, another missing link has just been found in the late Pliocene formations of Sussex, from those gravels which were probably laid down before the increasing cold of the Pliocene ranked its transition ages as Pleistoene—say, at a guess, a million years ago.

I have described elsewhere—following the conclusions of the discoverers and comparative anatomists—the Piltdown skull and lower jaw, which revealed to us as existing north of the South Downs at this comparatively distant period a creature, Eoanthropos, which was within the human family but in quite a different genus to modern Man. It had the underjaw and canine teeth of a chimpanzi and the brain capacity and nose of a human being. In close connection with these remains, moreover, were found primitive stone implements which, quite possibly, were used by this very woman (for the remains are probably feminine) when, in concert with the rest of the clan, she pursued wild game to kill and eat, or defended herself against their attacks when grubbing for roots.

So that the centre of Man’s origin may quite possibly have been Southern Eng-
land or Suffolk, or it may more probably have lain in France or South Germany. Putting one thing with the other, however, the most probable centre of human evolution was where the beliefs of Eastern religions have placed it—somewhere between Asia Minor on the north, Persia on the east, Arabia on the south, and the Mediterranean sea-coast on the west. From such a region Man, once he was really Man, and to some extent already master of creation, dispersed himself about the habitable globe.

In the genial intervals of many thousand years which intervened between the awful ice ages, he penetrated, no doubt, to Northern Siberia and the coasts of the Arctic Ocean. He forced his way through the dense forests of Equatorial Africa (chiefly, no doubt, along the sea-coast, feeding as he went on the luscious shell-fish) until he reached southernmost Africa whilst a monstrous fauna of mastodonts, gigantic horses and inconceivable buffaloes still lived there. In India he rioted and increased to millions—millions which colonised Ceylon, Burma and Java (where they found *Pithecanthropus* still lingering, though an acknowledged failure), and so on to New Guinea and Australia.

The further routes taken and the details of the human dispersal, I have related elsewhere.*

I have now to deal with the existing distribution of the one remaining human species, *Homo sapiens*.

Ancient, comparatively speaking, as has been the invasion of North and South America by Man, it was quite an afterthought in his career, and never, until the opening of the nineteenth century, was it so successful as his remarkable increase in all portions of the Old World, which, if we calculate it in proportion to the obstacles and natural difficulties he has had to overcome, has been amazing.

When men of the White race sailed from Europe in the fifteenth century of the Christian era and re-discovered America, they were certainly not the first Caucasian invaders of the New World. The adventures of Columbus, of Sebastian Cabot, Amerigo Vespucci, Cabral and Pinto, were the direct results of the Norse adventures in the ninth, tenth, and eleventh centuries previously.

A few hundred years after the opening of the Christian era, the long-headed, flaxen-haired and dark-haired White men of Norway and Denmark, and

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The Distribution of Man

probably of Western Germany likewise, had learnt to build comparatively large seafaring vessels, propelled both by oars and sails. Undoubtedly they gleaned this knowledge by indirect intercourse with Greece in connection with the amber trade. Greek adventurers reached the shores of the Baltic and the mouth of the Elbe in search of products of the northern coasts. From the time of the early Byzantine Empire these men of the Baltic and of the North Sea undoubtedly learned to make seafaring vessels in which oceans could be crossed.

Having thus developed the art of navigation, they set forth to ravage and to colonise, at one and the same time, lands more habitable, perchance, than their own wintry mountains and barren heaths. In the fifth and sixth centuries they began to make England out of Britain. Later they discovered and colonised the Shetlands and the Farœs, besides clutching at Normandy and making attempts to land even amongst the Moors of Morocco.

From the Farœs they sailed northwards in some summer voyage until they discovered Iceland (though it is said that Iceland had already been reached by bold seafaring monks from Ireland). From Iceland the Norsemen made their way to Greenland, and from Greenland to Newfoundland, Nova Scotia, and perhaps even New England. At any rate, they brought back from their overseas adventures wonderful stories of a "wine land," of a genial country, far across the Atlantic, usually conceived of as a series of large islands, where vines grew in abundance and where the indigenous natives were easily subdued.

But as a matter of fact these early White men's colonies in North America wilted and faded away, partly because the stormy Atlantic lay between them and the renewal of White colonisation, but more also because there descended on these tiny settlements a horde of warlike Eskimo that slaughtered most of the settlers and carried off others with them far to the Arctic north.

But Norway, always keeping in touch with Byzantium and consequently with Venice, was not reticent on the subject of the discovered lands across the Atlantic, and the tradition of their existence remained alive among the pilots of the Mediterranean until it inspired Columbus and Cabot and others to try once again to find what lay beyond the western horizon of Spain, Portugal and Ireland. By the close of the fifteenth century England had discovered Newfoundland and Cape Breton Island, Spain through Columbus had revealed the West Indies and the mainland of Central and South America, and Portugal had sighted Brazil.

During the sixteenth, seventeenth and eighteenth centuries America was "realised" by Europe. What did the history-writing men of Europe find to set down as the condition in human affairs of the New World before it was rediscovered by the intelligent people of the Old World? These pioneers of empire found probably the Western Hemisphere with a habitable area of at least 15,000,000 square miles, populated by the human species from the shores of the Arctic Ocean to the islands off the south end of Tierra del Fuego, islands that faced the Antarctic Ocean. Yet, probably, could they have estimated the aboriginal population of the New World they would not have been able to rate it at much more than fifteen millions for North and Central America, about two millions for the West Indies, and possibly twenty millions (if as much) for South America.

These are handsome estimates and it may well be that actuality fell below them. Very considerable areas of central North America from the Gulf of Mexico to the Arctic Ocean were uninhabited and given over to enormous herds of
Aborigines of the New World

bison, of prongbuck "antelope," of reindeer, moose, and deer of the peculiar American genus Mazama; to wolves, grizzly bear, black bear, pumas, and lynxes in proportion.

One can understand the reason of the sparseness of population in the Canadian Dominion of ancient days, for, except for the comparatively mild and well-forested regions of British Columbia on the west, and of the Great Lake region, Nova Scotia and Newfoundland on the east, the climate was so extremely rigorous for more than half the year, and such an enormous proportion of the area was un cultivated owing to the rocky soil or undrained peat swamp, that it only permitted the existence of nomadic tribes who lived on fish, deer and such wild grain or berries as could exist in the frozen north.

The thoroughly genial, well-provided lands of California, on the one side, and of New England on the other, of the Mississippi Valley and of Florida, do not seem at any time in their history to have had a very dense human population, even as compared with Central America, which was perhaps for its area the densest-peopled part of aboriginal America. The ancient population of Mexico was thin except in the south and centre. As to the once civilised and no doubt abundant natives of Honduras, Guatemala and Nicaragua, something seems to have afflicted them and destroyed them long before the Spaniards landed. It has been surmised by some American writers that this "something" was germ-diseases, malarial fevers—suddenly generated by the coming into existence of a transmitting agency.

All the West India Islands were populated when they were first discovered by the Spaniards, except such as were very small in area and far away from any land mass of size. Apparently, they had received their population from two directions: — From Yucatan and Honduras across to Cuba and Jamaica, but mainly and more recently from northern South America.

From this direction had come first the Arawaks, whose race still lingers in slowly diminishing numbers in Guiana; and afterwards the bold cannibalistic Caribs, who followed up the gentle Arawaks that had populated the Windward and Leeward Islands, and the large islands of Porto Rico, Haiti and Cuba. The Caribs literally ate up the Arawaks in the smaller West India Islands, and persecuted them in the Greater Antilles by constant raids on their coasts.

The Arawaks of the West Indies were extinguished by the Spaniards and to a lesser degree by the British in about two hundred years of colonial administration. But with very little intermixture a portion of them still subsist in the

HAWAIIAN FISHERMAN CATCHING CRABS
The indigenes of the Hawaii Archipelago (now only about 70,000 in number) are being gradually absorbed or crowded out by Americans and Japanese
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eastern part of Cuba. They are styled Cubans and Christians, but they are nothing else than Arawak Indians speaking Spanish and living like the lower orders live in Spain.

There is no proof that the great basin of the Orinoco or the lofty plateaux of Venezuela, the vast basin of the Amazon and its affluent s, the plateaux and mountains of Brazil, and the plains and pampas of Argentina, Chile, Patagonia, or sodden, semi-frozen Tierra del Fuego, were ever very largely inhabited, though on the whole ancient Man took a much stronger hold over South and Central than over North America.

The “Indian” tribes of all these regions just enumerated had certain affinities, and they none of them rose above a level of culture which was shared with the aboriginals of North America and the West Indies. They were mainly hunters, living on game and fish and wild fruits, and practised comparatively little agriculture. Such as was practised was mainly confined to the eastern part of genial North America, to northern South America, and to the West Indies.

The nomad tribes of Argentina, Paraguay, Brazil, Patagonia and Tierra del Fuego remained in the hunter stage until they were conquered by the Spaniards and Portuguese. But although the whole of North America (except so far as the Eskimo were concerned, and they may have derived the elements of their civilisation from the Norse invaders of Greenland and Nova Scotia and all the eastern and southern part of South America, together with the West India Islands, were mainly in a state of savagery, there had arisen a very remarkable civilisation in Central America and in Andine South America. This civilisation may even be traced in a diminished degree northwards as far as Colorado in the United States, but not apparently into California.

It radiated chiefly from three great centres in between which savagery still reigned when the European conquest began. These foci were the central plateau of Mexico, the lofty mountain region of Colombia, and the Inca Empire of Peru; and to a certain extent the civilisations which radiated from Mexico, Colombia and Peru showed not only kinship in character and origins, but the dominant human type had a great similarity in appearance.
Ruling Races of Central and South America

It is a type rather easily defined, with a pyramidal head form brought about by artificial means, rather Mongolian eyes, a very prominent, curved nose and somewhat retreating chin—a type with a curious supercilious look about it and no strongly marked sexual features: that is to say, the grand old men might just as well be grand old women, the emperors if dressed accordingly would easily be mistaken for empresses. Of all the types outside America most readily recalled by these ruling races of Peru, Colombia and Central America is that of the aristocratic Japanese.

One is impelled irresistibly to the conclusion that this remarkable Neolithic civilisation of the western side of Central and South America was not indigenous but arrived from some such region as Japan; and it is far from improbable that after the Japanese themselves had become civilised, their seafaring vessels may have been driven by winds across to Alaska, and that they may have passed southwards from that region of glaciers to the genial lands along the west coast of Central America.

Or again, other Indonesian adventurers from Eastern Asia may first have explored Polynesia and finally have landed on the coast of Peru to reinforce the Asiatic culture from the north.

The lower classes of Peru and of other South and Central American states, as distinct from the aristocracy, and all the tribes of savages in other parts of Tropical America, frequently recall very strongly in their facial appearance the indigences of Borneo and of the more northern Pacific islands, and in their head form suggest resemblances to the ancient and modern “Moriori” types of the New Zealand Dominion.

Probably in bygone times America had been colonised not only by way of
The Distribution of Man

Behring Straits—whence was derived undoubtedly the bulk of its ancient peoples in one of the genial ages of the Pleistocene—but also by way of the Pacific archipelagoes. The mysterious stone ruins, buildings and carvings in the Pacific islands have features about them which recall irresistibly the mastery over stone acquired by the Peruvians and Central Americans.

At the present day, therefore, in considering the distribution of the many varieties and types of the human species, we have to allot to the Americas three divisions of existing humanity: the Amerindian (which is obviously a compact of ancient intermingleings between Mongolian and Caucasian, with a dash perhaps of something more primitive and Australoid); the Caucasian in the form of the Nordic and Mediterranean peoples—the descendants of the English, Scottish, Irish and Welsh; Bretons, Frenchmen and Basques; Icelanders, Norwegians and Swedes; Germans, Magyars and Slavs; Greeks and Syrians; Italians, Spaniards and Portuguese—and the Negro.

The Negro entered the New World on the ships of the Caucasian. Whilst Spain was conquering the West Indies and Central America, Portugal was beginning to control the west coast of Africa. As soon as the remonstrances of the Spanish priests called the attention of the Emperor Charles V. to the extermination of the aborigines in the West Indies and to their unsuitability for heavy industrial work, he commenced sending Negroes from Southern Portugal and North Africa to America.

Industrially and commercially the experiment was a success—to such a degree that as early as the first half of the sixteenth century Negro soldiers and even officers were enabling the Spaniards to conquer the southern part of North America and the Panama isthmus.

When the French, the Dutch and the English claimed their share of the New World, fifty to a hundred years later, they promptly adopted the same plan. They imported Negroes from West Africa to do all the hard work in the sun-smitten parts of America. By the end of the eighteenth century there must have been about a million Negroes in North America, another million in Central America, two or three millions in the West Indies, and five or six millions in South America.

The total Negro and Negroid population of the New World now is 25,000,000, and it scarcely shows a tendency to diminish anywhere, but rather to increase. It pushes away or it absorbs the Amerindian, sometimes creating with the latter rather a fine-looking hybrid. The Negro has run wild again and reverted to an almost savage and perfectly naked type in the forests of Guiana and in some parts of Brazil, of the West Indies, and even of the south-east coast of North America.

On the other hand, in Brazil, in the United States, Jamaica, Barbados, Bahamas, and even much derided Haiti, there are Negro statesmen, scientists, doctors, clergymen, and writers, fully worthy to be ranked with the best in such orders in Europe or in America. Yet in some parts of Haiti I have seen Negroes literally without a scrap of clothing, leading a thoroughly happy and quite harmless life on the lakes or in the forests.

But in the Haitian towns, raeked as they are by preposterous political disturbances, I have met men with whom it was a pleasure and a profit to converse, so witty were they, so extraordinarily well educated. Some of the greatest military leaders in the recent history of the two Americas have sprung from the Black race. However unpalatable such a conclusion may be to the White man, a great future lies before—I will not say...
America in the Ascendant

Black America, but Pale-brown America; for one result of leading a thoroughly civilised life in a temperate climate seems to be by slow degrees to pale the colour of the Negro skin.

But in addition, here also, as in Africa, White blood is very potent. If the Negroids have multiplied in four centuries to 25,000,000, the White race Negro fold, carrying thither their tribute of White blood and thereby refining the features, sharpening the intellect, lightening the skin colour, and loosening the hair of the American Negro.

We should realise that this process has been going on for ages in Africa itself, so that, as I have stated elsewhere, there are very few really Negro

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A BATAK FAMILY OF NEGROID MALAYS, SUMATRA

In the islands of the East Indian Archipelago there are three race elements still distinguishable at the present day—wild Negroes or Negroids in the dense forests, Caucasian-like Indonesians on the coast or in the mountains, and Malays (Oceanic Mongols) everywhere else

has increased in North and South America to 150,000,000. During all the centuries of slavery the White races, no matter what their origin or how aristocratic their pride, interbred with the Negro without restraint, and innumerable hybrids sprang up. In the last fifty years the tendency has been for this direct mixture between the two widely differing races to cease; consequently, instead of White men marrying half-caste or quadroon women, these latter now marry back into the races to be met with in Africa—types, that is to say, in which one could not indicate here and there the result of ancient or modern intermixture with the White man from the north.

The present population of the Americas of all these three races and of their intermediate types, of the few East Indians that have come there, and of the larger numbers of Japanese and Chinese (perhaps 2,500,000 in all) amounts to the total of 194,000,000, as against the estimated total of 1,540,000,000 which
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would stand for the population of the Old World (Eurasia, Australasia, and Africa).

I begin to fear (being a European, and consequently having a preference for the Old World) that the New World is in the ascendant. South America is less unhealthy for all types of man—Black, White and Yellow—than Africa, a little less afflicted with germ-diseases and deserts, that is to say. The West Indies are earthly paradises, only ravaged by occasional hurricanes or earthquake shocks, the damage from which is in reality very slight and easily repaired. Central America is another glorious region, regarded as a home for humanity, and almost the whole of North America is habitable by Man except Greenland and the really Arctic portion of the vast Canadian Dominion. Very little of Alaska can be described as absolutely uninhabitable. The whole of the New World from the Arctic to the Antarctic is extraordinarily rich in what man requires for his now complicated existence—in minerals, in soils fitted for the produce of the best types of vegetable food, in areas for cattle and sheep raising, in forests not only full of timber but of valuable food products and countless essences and drugs. And last, but not least, there is a lavish abundance of magnificent, of cheering or of inspiring scenery.

Yet for a long while to come, by sheer weight of peoples, and by the enormous prestige of history and the increasing reverence that we give to the birthplaces of art and of civilisation, the Old World must take the lead. Perhaps, indeed, that other New World, Australasia, may assist us to redress the balance when America is running neck and neck with our descendants.

Australasia possesses still (though its White people are not sufficiently conscious of the privilege) what may be described as the oldest of existing human races: the Australoid. Of all living human types this comes nearest to the Ape ancestor, and though it seems to have inhabited Australia and perhaps Tasmania for one or even two hundred thousand years, or perhaps more than that, it is much more likely to have originated in Western Asia or even Central Europe, and to have sprung directly from the half-simian type which gave birth to the genus Homo. The Australoid is slightly nearer to the Ape in his physical conformation than are any types of ancient fossil Man excepting, of course, Pithecanthropos and Eoanthropos.

The extraordinarily interesting, almost black-skinned Australoid, with his hairy body, his unkempt, slightly curly hair, and well-bearded face (whiskers appearing even amongst the
IN THE NATIVE QUARTER, COLOMBO, CEYLON

Primitive Man dispersed himself about the habitable globe from a centre probably in the neighbourhood of Asia Minor. In India Man rioted and increased to millions, which colonised Ceylon, Burma and Java, and so on to New Guinea and Australia.
women), still exists in the Australian Continent to the extent of about 70,000 or 80,000, confined chiefly now in their range to the north-east, north, and north-west.

Down to about 1876 there existed representatives of an even more interesting variety, the Tasmanian or aboriginal race of the large island of Tasmania. These, though they had many points of affinity with the Australoid, were equally akin to a generalised Negro type, and consequently to the Oceanic Negroes of the Solomon Islands and of New Guinea. Ancient intermixture between Australoid and proto-Negro no doubt produced the Melanesian on the Western Pacific; and very likely the Melanesians or the Oceanic Negroes reached as far as New Zealand in their canoe voyages from the direction of New Caledonia and Fiji. There is, at any rate, undoubtedly an ancient Negroid element in the modern Maori.

The Maoris of New Zealand, numbering still about 75,000, show at least two distinct types, besides intermixtures between the two extremes. There are Maoris of Polynesian ancestry, descendants of adventurous colonists who came from Samoa and other islands to New Zealand 600 or 700 years ago. Some of these, especially amongst the men, almost have the facial outlines of Europeans. They are made ugly in our eyes by the hideous tattooing, but in the later generation which has become quite civilised and given up such absurdities, the facial appearance is not unlike that of the average North African type. That is to say, they are Caucasians with a slight dash of the Negro and the Mongol. The lower class amongst the Maoris is more like the Melanesians of the New Hebrides and Fiji, and undoubtedly came from that direction.

In New Guinea the population may be roughly divided into three types. Preponderating in numbers and influence are the Papuans.

The Papuans are a tall people, of not unpleasing appearance, with great mops of frizzly hair, and the black skin of the Negro, but differing from the Oceanic Negro in having arched or even hooked noses of quite a Jewish appearance. The next most abundant type is the almost-Negro Pygmy of New Guinea, who, except for his having a rather more prominent nose bridge, offers a remarkable resem-
New Guinea and Adjacent Islands

blance to the Pygmies of Central Africa. The third element here and there on the coasts of New Guinea and its adjacent islands may be described as Polynesian.

This is either derived quite recently from Polynesian colonies of the Pacific archipelagoes far away to the east, or it has an even more interesting origin. It perhaps belongs to that “Indonesian” type met with here and there in the Malay Archipelago, probably colonies of the ancestral Polynesians who stopped at the outlying islands of New Guinea on their eastward migrations.

These Indonesians very likely were proto-Caucasians who may have been distantly connected with the “hairy” Ainus of Japan and of Sakhalin, or even with the ancient Aryan conquerors and colonisers of Central Asia. They may have found their way through the forests of Malaysia and Indo-China to the coasts of Sumatra, of Java, and still more certainly of the great islands lying to the east of Celebes.

In some such islands as these there are three race elements at the present day still distinguishable—wild Negroes or Negroids in the dense forests, Caucasian-like Indonesians on the coast or in the mountains, and Malays (Oceanic Mongols) everywhere else.

In the Solomon Islands and perhaps the Admiralty Islands, to the north-east and east of New Guinea.

Traces of an ancient Negro type are
AN ASSEMBLAGE OF CHIEFS, UPOTO, UPPER CONGO
The Missing Link

still to be seen (quite apart from recent slave intermixture) in Eastern Arabia and the shores of the Persian Gulf, in many parts of India (India must have been anciently quite a Negro land), in Burma, in the adjacent Andaman islands (where the native population is pure—and pygmy—Negro), in the forests of the Malay Peninsula, in Annam, the Philippine Islands, Sumatra, Celebes, Flores, Timor, Buru, Ceram, and Jilolo. Curiously enough, the Negro type, so far as we know, is entirely absent from Borneo and probably also from Java and Sumbawa.

It would almost seem as though the ancient Negro invasion of Oceania had sent its main stream across Burma into Indo-China and thence into Sumatra and the Philippine Islands (whence by way of Formosa and the Riu-chu Archipelago, an Asiatic Negro strain even reached anecdotely to Japan, and now still shows itself in the physiognomy of the southern Japanese). From the Philippine Archipelago, Negroes made their way into Celebes, Jilolo, and the other great islands lying to the south, and into New Guinea, whence they penetrated to the Solomon Islands, the New Hebrides, New Caledonia, Eastern Australia, and Tasmania, and also, far away to the north-east, to the Hawaii Archipelago.

How such a primitive and savage type of man, with a form of culture which scarcely reached to the dug-out canoe, could have made its way over the wastes of the Pacific waters, which have proved too often dangerous even to well-equipped sailing vessels of the eighteenth and early nineteenth centuries, is one of the many unsolved mysteries of the history of man. Possibly within the last hundred thousand years or so there have been great subsidences of lands which may have previously linked up these islands with one another. Perhaps, even, the Oceanic Negroes developed a greater degree of civilisation in the past which they have subsequently lost. More probably they were early enslaved by the intrusive Mongols and Caucahians, and have been conveyed to all these distant islands as slaves and concubines. There they are to be found, at any rate, at the present day.

On the other hand, in what is called Micronesia (the Caroline and Marshall Archipelagos), there is little or no trace of Negro intermixture. The indigenes are more Mongolian in type than are the Malay, and even offer tantalising resemblances in many points to the aborigines of South and Central America.

Java is an island with an interest about it wholly disproportionate to its size, which is far smaller than that of Borneo or Sumatra. In Java, as we know, were found the remains of a real missing link—Pithecanthropos, a creature in many ways intermediate between the lowest type of man and the highest type of ape, with perhaps a greater leaning towards the human family. But in Java, so far, have been found no distinct traces of a Negroid people, or of anything especially Australoid.

There was much talk at one time of a
now extinct tribe in the forested mountains, known as the Kalangs; they were round-headed, however, and excessively prognathous, but seemingly more related to the primitive stock of the Mongols than of the Negroes.

A Negro or Negrito population of marked type is still to be met with in the great island of Mindanao, the southernmost portion of the Philippine Archipelago, as well as in Luzon and other islands of that group; in the interior forests of the Malay Peninsula and in the islands off the east coast of Sumatra, as well as in the southernmost portion of that great island. The fact that the Andaman Archipelago is peopled by an absolutely Negro race (sometimes called Negrito because of their small size) has already been mentioned, and an allusion has been made to the Negroid forest tribes of Southern India.

The Negro sub-species of Man, it has been mentioned, probably originated from a generalised Australoid stock, in short, from the primitive beginnings of Homo sapiens, in Southern or Western Europe. Negroid remains of about thirty or forty thousand years ago—perhaps even more ancient—have been found at a depth of twenty-seven feet below the surface soil of certain caverns on the French Riviera, and somewhat similar remains of less ancient date have been detected in old burial-places in Italy, Western France, and Sicily. The oldest skulls as yet found in the Pleistocene and even Paleolithic fossil-bearing ground of Algeria, likewise indicate a Negro or Negroid type.

The very remarkable illustrations graven on slate palettes in Lower Egypt by the early dynastic Egyptians, would seem to show that the primitive inhabitants of the Nile delta were pygmy Negroids extraordinarily like in facial appearance the pygmy Negroids of New Guinea at the present day. They more resembled this Asiatic type of Negro or Negrito than they do, for example, the pygmy Negroes of the Congo Forest, because the nose is more prominent and has a higher, more curved bridge; otherwise there is much about them and their surroundings which recalls the pygmy Negroes of Central Africa. We can trace this Negro or Negroid type into Syria, where it was evidently the basic population many thousands of years ago, and (as already mentioned) across Arabia to Mesopotamia and the Persian Gulf.

The Assyrians were remarkably Negroid (though perhaps in an Asiatic rather than an African sense) in their appearance, and transmitted some of these characteristics to that very much mixed and diverse human race which we know as Jews, as well as to the Aramaic population of Syria. Into Babylonia, however, came in early times a more Mongolian type from the north, and later there were Nordic or Aryan invasions which, though they may have left no linguistic traces farther west and south
Human Invasion of Africa

than Persia, nevertheless obviously penetrated across Syria even into Egypt. Many of the northern Arabs, some of the Syrians and the Jews, though they may or may not be slightly tinted in skin complexion, have facial features recalling those of Central, Northern, and Western Europe at the present day.

Quite possibly the human invasion of

and long upper lip than any other surviving examples of primitive Man.

But the main coloniser of Africa was the Negro; the Negro in two types, perhaps, to commence with: firstly, the true Negro, ranging in stature from a pygmy of four feet six to a giant of six feet two (but ordinarily of average stature), with short legs and long arms,

Africa began before the Negro type was specialised. The first men that wandered through the Dark Continent may have been very like in appearance to the modern Australoids, or even a little more simian in features and physical conformation. There was little or nothing to stop their wandering right down to the southern extremity of the Continent, where, indeed, may be met with at the present day, amongst the Bushmen, living types that are more ape-like in their projecting muzzle, flattened nose a rather hairy body in the male, and very dark, almost black skin; and, secondly, the Bushman. The Bushman was a Negroid type that may have begun to specialise in Southern Europe and the Mediterranean basin. As regards stature it may have been originally normal, and only have tended to dwarfishness when restricted to a hard life in the arid deserts. The Bushman had retained a much lighter skin colour than the original Negroid ancestor, or on account of his existence in the open in sandy regions

PYGMIES OF THE NORTH-EAST CONGO FOREST

Until Schweinfurth, Livingstone, and Stanley penetrated into the heart of the African Continent, the very existence of these most interesting little people was popularly believed to be a myth.

Photo by the late Rev. George Grenfell

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this skin colour in course of time may have become lighter: at any rate, the Bushman, on the whole, is a yellow-skinned man as compared with the dark chocolate or brownish-black of the true Negro.

In some directions the Bushman specialised in physical features, especially in the hairlessness of the body and the intensely-tight curling and segregated growth of the head-hair. He also developed a rounder skull than that of the Negro, a fatty protrusion of the rump, and other peculiarities. The Bushman seems to have migrated from the Mediterranean basin down through the Valley of the Nile into Somaliland and East Africa, and to have had at one time some special concentration in the regions south-east of the Victoria Nyanza, where he has left to this day traces of his extraordinary click language—a type of speech which comes nearer to the inarticulate and the brute utterance than any other known language at the present time. Pushed ever southwards he chose the line of least resistance, and skirting the dense forests of Central Africa, spread out over the Zambezi basin and made trans-Zambebian Africa specially his home. He also wandered northwards again from the Zambezi basin and established himself in Southern Angola between the Kunene and the Okavango.

The Negro proper was pushed out of North Africa and Egypt by the incoming White men of the later Palaeolithic and of the Neolithic ages. He travelled across the Sahara Desert, not then so fiercely arid as to-day, and up the Valley of the Nile. He found on the whole the climatic conditions of the Sudan—as we call that vast region of North tropical Africa between Abyssinia on the east and the Atlantic coast of Senegambia on the west—very much to his liking. He increased and multiplied to a great degree and populated all this broad stretch of Africa by millions.

But he looked somewhat askance at the great forests of the equatorial zone; as we have done—ages and ages later on—through the eyes of our pioneers. Nevertheless, into this forest had penetrated, through force of circumstances, the earlier Negro arrivals—the Pygmies. Here in course of time they made themselves at home, though they probably never really multiplied to anything like the extent that the bigger tribes were able to do in the more open spaces. There may have been Bushmen in the upper bend of the great Niger River, and Bushmen round about Lake Chad; but if so, they were absorbed by the incoming bigger Negroes of darker skins and taller stature, and have only left slight traces of their former presence in legends, in language influence, and in the faces of some of the existing tribes.

Negroland proper, therefore, at one time in the history of Africa, was more or less confined to a broad belt south of the Sahara Desert stretching from Senegambia to the northern basin of the Congo, to the Great Lakes, to Abyssinia, to the Nubian Nile, and to the Zanzibar coast. The Negro seemingly never penetrated into Somaliland or much into the mountains of Abyssinia; and in West-Central Africa only crept timidly past the Cameroons down to the Congo and Angola coasts, and perhaps also reached the Zambezi basin from the direction of Zanzibar. But he left the densely forested centre of Africa to the Pygmy, and trans-Zambezia practically to the Bushman.

About this stage in the history of Africa—it may have been 50,000 to 30,000 years ago—there enters a mysterious element, known by the Dutch name of Strandloper (“shore-runner”). The Strandloopers, as far as we can estimate them from their earliest skulls found in South African caverns and
White Colonisation of Africa

gravel-pits, were scarcely more than Negroid; they were rather more akin to the primitive Caucasian type which had begun to develop in Europe from out of the Australoid. They had somewhat rounded skulls, and considerable brain capacity, superior almost to that of the highest type of the modern European; and they showed this also by the character of their stone implements.

Their remains are associated with a vanished fauna, though how recently these strange South African mammals became extinct, we do not yet know. They included one of the latest survivors of the Mastodon family of elephants, a gigantic horse or equine, and a buffalo similar to the North African one, with enormously long horns. These Strandloopers, moreover, had the same wonderful gift for drawing that we find in the cave men of Palaeolithic Europe and the Neolithic draughtsmen of North Africa.

Apparently, the Strandloopers were more or less associated with the early Bushmen and taught them this art of drawing. Gradually—we find in our researches—as the skulls grow less ancient, they become more Bushman in type, until finally they are those of Bushmen. If we have read rightly the slender evidence there is in artefacts and fossil bones, we may regard the Strandloopers of southernmost Africa as the earliest invasion of Southern Africa by the European.

Between 20,000 and 10,000 years ago we may surmise that the White man made very decided attempts to colonise Africa. Perhaps there were still fragments of the old land bridge remaining which in Pliocene and early Pleistocene times connected Sicily and Malta with Italy and Tunis. Palaeolithic and Neolithic Europeans may thus have made their way to North Africa by land as their Negro predecessors had done. In any case, by this time the Straits of Gibraltar had become as narrow as they are to-day (they were once much broader), and the European having learnt to make canoes and rafts easily passed over to Morocco.

The first "white" invasion of North Africa on a large and determined scale seems to have come from Syria and Arabia across the Isthmus of Suez, or the narrow Red Sea. These invaders were the ancestors of the Kushites—the speakers of the more primitive Hamitic languages such as Gala, Somali, Hadendawi. A later phase of similar invasion was seen in the dynastic Egyptians (a Hamitic-speaking people of Caucasian race, and similar in features to modern Europeans) who had no doubt long dwelt in Western Arabia, where the gradually increasing drought forced them to adopt more and more ingenious methods of storing water and therefore inducted them into the arts of masonry and stone quarrying. Over population, tribal wars, or increasing drought compelled them to seek other homes across the Red Sea.

They colonised first of all what we now call Eritrea (Italian North-East Africa), and then advanced across the desert till they reached the Nile below Dongola. From this and other directions they penetrated into the lower Nile Valley and established themselves as a ruling race below the last of the cataracts. By degrees they advanced towards the delta, till at last they were masters of the whole of Egypt, of the narrow cultivation area of the Nile Valley and its fan-like delta. They never quite absorbed or excluded the Libyans or Berbers, however, who persist in isolated colonies to the present day as near the Nile as the oasis of Siwah, and who in the decadent times of Egypt frequently became the rulers of the country and supplied Libyan dynasties.

The ancient Egyptian language was akin both to the Semitic and Hamitic
The Distribution of Man

branches of what 15,000 or 20,000 years ago was a single mother speech somewhere in South-West Asia. But in course of time and by long dwelling in the Valley of the Nile and contact with both their Gala predecessors and the incoming Libyans, the Egyptian language took on a more distinctly Hamitic

cast; only, however, to be again Semitized when the developing Semites of Syria and North Arabia in their turn began to invade and colonise Egypt in increasing numbers.

We know the outcome of all these movements in the present mixed population of the northern third of Africa. Hamites, speaking the parent languages from which the Libyan dialects of to-day are derived—languages near akin to the Semitic and originating somewhere in Armenia or the Caucasus—spread from Egypt through Tripoli to Tunis Algeria, and Morocco, and southwards into Abyssinia, Galaland and Somaliland.

The whole of this region from the Somali coast in the east to the Canary Islands in the west, began to use but one language type, that of the modern Berber or Libyan, the Gala, Somali, or Bisharin. Their ancestors were not perhaps absolutely white-skinned, and they had certainly mingled on the way with Negroids, Bushmen, and ancient Australoids stranded in South-West Asia. They represented, probably, the intelligent Neolithic population of all North Africa, and their outposts extended into many of the Sahara oases. They possibly found considerable Negro colonies still living in the Tripolitaine. With these and the Nubians of Upper Egypt they mingled, producing hybrid races which persist to this day in the form of the Tibu or Teda and the Kanem.

Then—12,000 years ago—there came a great invasion of Mauretania from the direction of Spain, an invasion by that same Iberian race which later on was to colonise all Britain, France, and much of Central Europe. These Iberians, who really were White men—even in some cases White men of the Nordic type with brown, red, or yellow hair, and grey eyes, but for the most part strikingly handsome men and women of clear pink and white complexions, dark hair, and brown eyes—mingled with the Hamites in North Africa and adopted their language, discarding their own, which it is quite likely may have been akin to the modern Basque and to obscure tongues of the South-West Caucasus. They advanced eastwards along the north coast of Africa till they had colonised much of lower Egypt and possibly even sent detachments into Abyssinia and Palestine (the Amorites).

In Mauretania to-day we have some
THE "KABAIL," OR BERBERS OF EASTERN ALGERIA

The "Kroumir", or Khmirs of 1881-82, which were the cause of the French invasion of Tunis, belonged to this stock, as do most of the hill tribes of Tunis, Algeria and Morocco.
tribes that are simply handsome "Europeans," who in different costumes might pass for Spaniards, French, or Italians; others which, though of European lineaments, are much too dark-skinned to be anything but African; others again that are Negroid or actually Negro; while some are of pure Greek profile and pink and white complexions. Others again are Jews or are like Jews, or resemble in the most emphatic manner the hawk-eyed, eagle-beaked people of North Arabia.

We know historically that the Phoenicians of Syria established many colonies on the North African coast between 1,000 B.C. and the fall of Carthage; that the Romans succeeded them as rulers and founded numerous Latin settlements in North Africa which left words behind in the Berber tongue and a very Italian look in the faces of some of the coast populations. Both before and after the Romans came the Greeks, especially to the coast of Tunis. Then followed the Arab conquest in the eighth century of the Christian era, in which period likewise began the Arabisation of Egypt. But both Egypt and North Africa did not receive their full contingent of Arab population till later centuries, especially the twelfth.

With or after the Arabs came the Turks, who brought with them captive Slavs from Europe, Kurds from the Persian border, Circassians and Albanians. As soon as the Maltese (who were of mixed Italian and Phœnician origin) prospered under British rule, they too sent large contingents to the towns of all North Africa from Egypt to Morocco. Many French, English, German, and Hungarians followed during the nineteenth century, so that in the whole of North Africa at the present day we have every range of facial lineament and complexion, from the whitest skinned European to the black Negro of Bornu.

The Sahara Desert is sparsely populated (wherever there is any spring of water) by the Negroid Tibus in the east, and by the Tuareg (who are Berbers) in the west. In some of the oases there is a Negroid population derived from the slave trade, which began after the Roman conquest of North Africa. The Tuareg are simply Berbers or Libyans who fled from Tunis after repeated reprisals for insurrection at the hands of the Romans, Byzantines, or Arabs. It is said that when they reached the oases of the western Sahara they found these "islands" of vegetation already occupied by adventurous Jewish colonists. The Jews came to North Africa in the wake of the Phœnicians and before the destruction of Jerusalem. After that event, however, the Jews that migrated from Palestine mainly established themselves in Cyrenaica (once a Greek colony), in Tripoli, Tunis, Algeria, and Morocco. Before the coming of the Arabs in the eighth century they wielded great influence and had nearly converted all the Berber tribes to Judaism. It is quite possible, therefore, that they carried the White man's bold spirit of adventure into the Sahara Desert, and reoccupied oases which had been abandoned since Neolithic times.

South of the Sahara Desert, however, the lands remained mainly in the possession of a purely Negro population, but with one or two important exceptions. Arab tribes had invaded southern Bornu, Darfur, and Wadai, and their influence was potent and far-reaching. Arab religious teachers accompanied by Arab craftsmen had brought much civilisation to the western Sudan.

But there also existed in the western Sudan the remarkable Fula people. These seem to have had their first great centre of distribution in the desert mountains to the north of the Lower Senegal. In fact, if one may trust local traditions, they had anciently inhabited the west and south-west of Morocco, and
The Ful Race

had been driven out of that region by the Berbers. They may, indeed, be remnants of the Neolithic White race that colonised all North Africa and drew those wonderful pictures on the slabs of rock, depicting beasts that are now extinct or which have long been exterminated in North Africa. In any case, when intelligent Europeans first came to know West Africa and the western Sudan, they found tribes, in some cases settled, in others nomadic and cattle-keeping, that could not be classed as Negroes; nor were they Berbers from across the Desert, or Arabs. They belonged to the Ful race.

Their faces were like those of Arabs or even of the better-looking Berber, but the hair was not quite straight; it was ringlety, looking as though it had been crimped. Their physique on the whole pointed them out as a White rather than a Negroid race; their language, however, somewhat resembled the great families of Negro speech in West Africa.

Since the sixteenth century, when the Ful were first noticed by the Portuguese, they have spread far and wide as a dominant and conquering race, and until Britain and France took serious hold of West and West-Central Africa there were large Fula kingdoms and empires stretching from the back of the French colony of Senegal to the vicinity of Lake Chad. There were even Ful colonies of unknown history in Darfur. The Ful had embraced the religion of Islam as early as the tenth and eleventh centuries, and became in course of time fanatic Muhammadans. Their constant pilgrimages to and from Mekka introduced into the heart of West-Central Africa a great deal of Asiatic civilisation.

The Hausa are an interesting Negro people of the central Sudan. They number from 10,000,000 to 15,000,000, and are the dominant type between Bornu and the central Niger. Their language is a kind of compromise be-
The Distribution of Man

tween the speech of the Hamites and that of the Negro, and their civilisation is comparatively ancient and is obviously derived from Egypt and from North Africa.

A good many Negro tribes of the great Sudan show signs of ancient Caucasian invasion or intermixture, but others again are extreme in their type of Negro physiognomy. The whole Sudan north of the upper Congo and the equatorial belt is emphatically the land of the Negro, and it is here that two-thirds of the Negro population is concentrated. In the valley of the upper Nile, however, the Negroes developed a special type both in language and in physique. This last tends towards the gigantic; in fact, in the Turkana tribe which dwells on the west coast of Lake Rudolf, the average stature of the men is not much under seven feet. But it is a type that runs a good deal to leg, and therefore is in direct contrast to the Forest Negro of West and Central Africa, with whom the legs are rather short and the arms rather long.

An intermixture of all these Negro races, with here and there a dash of the Bushman, has produced what we call the Bantu. It is difficult to define any Bantu physical type because this average Negro of well-proportioned body and fine muscular development is to be met with in West Africa far outside the range of the Bantu languages. But in pursuing the ancient history of Africa as indicated by the evidence we can gather together, we seem to realise that densely as the whole Sudan was populated, the Negro found the forests of the Congo basin so serious an obstacle that he was a good deal delayed in his colonisation of the southern third of Africa, which, as we have already noticed, seems to have been chiefly initiated (except along the coasts of Zanzibar and Angola and up the Zambezi valley) by Congo Pygmies and Bushmen.

Yet somewhere in the very heart of Africa between the basins of Lake Chad, of the western Nile, and the northern Congo, there must have arisen a remarkable warrior tribe with an almost Hamitie aristocracy—the original "Bantu" people, who spoke a language largely governed by prefixes and distantly akin to other language families of West-Central and Western Africa. Such a people—the original Bantu—about 2,000 to 2,200 years ago, must have invaded with a rush, occupied and colonised the regions of the great Nyanzas or Central African lakes.

They spread to the Zanzibar coast down the Wele and Mubangi and upper Kunene Rivers till they reached the Cameroons, the Congo and Angola litoral, and past Tanganyika and Nyasa to the south of the Congo basin and to the Zambezi. For a time they halted at the Zambezi, then, impelled by other peoples pushing from the north, they had crossed that river about the ninth, tenth, and eleventh centuries of the
Origin of the Hottentots

Christian era. Thenceforth they made themselves masters of all South Africa except the more arid western half which was still restricted to Bushmen and Hottentots when the White people discovered it and colonised it between the seventeenth and the nineteenth centuries. Consequently the whole of the

Who were the Hottentots? They seem to have arisen from a minor race movement as compared with that of the Bantu, but occurring much about the same time as the era of the great Bantu dispersal. Possibly they were a people mainly of ancient Bushman stock and speaking one of the Bushman dialects,

southern third of Africa at the present day is populated for the main part by Negroes of an average Negro type, all speaking languages of one family—the Bantu. There still remain a few Bushmen and Hottentots in South-West Africa and the Pygmies in the Congo forests, while in several of the mountain regions of Equatorial Africa you may see still remaining the handsome Hamitic aristocracies which once, no doubt, gave point and emphasis to Bantu conquests and Bantu civilisation.

who came a good deal under the influence of early Hamitic invaders of Eastern Equatorial Africa, south or south-east of the Victoria Nyanza. From them they derived domestic cattle, some of their simple arts and most of their legends; and their language received a moulding at the hands of these superior friends or enemies which gives it still an illusive resemblance to the Hamitic languages.

The Hottentots (see opposite) who also mingled a good deal with the Bantu Negroes in their migrations, seem to have

ESKIMO WOMEN AND CHILDREN, KING'S ISLAND, ALASKA
The Eskimo may have derived the elements of civilisation from Norse invaders of Greenland and Nova Scotia

Photo by courtesy of Dr. George B. Gordon

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The Distribution of Man

passed from “German” E. Africa, south of Tanganyika, across North-Western Zambezia, till they reached the Atlantic coast, down which they wandered until they finally discovered a beautiful country to occupy in southern Cape Colony.

In Madagascar we find—as did the first Arab and Portuguese discoverers of that island—a people more or less Negroid in appearance, but speaking only one type of language, and that utterly unconnected with Africa but closely allied to the Malay and Polynesian languages of Malaysia and Oceania. Some of the interior Malagasy tribes, however, differ from those nearer the coast, are of taller stature, darker skins, and more Negroid type, and resemble much more the Japanese or Javanese. An example of this very Mongolian form of Malagasy is seen in the celebrated Hova race which dominated the island down to the French conquest. The Hova seem to be descendants of the last Malay colonisation of Madagascar, perhaps an event of as ancient a date as the sixth or seventh centuries of the Christian era. They arrived on the east coast of Madagascar, but finding the malarial conditions unhealthy, conquered and colonised the central plateau.

The population of the Canary Islands when it was first discovered by Normans, Genoese, and Spaniards between the twelfth and fourteenth centuries, was closely akin to that of Morocco, and evidently “Guanche” was a branch of the Libyan language. In short, they were White men, but living in rather a primitive Neolithic style when first discovered; so much so that the men frequently went in complete nudity.

The population of Europe remains to be considered, but need not occupy us long, as so many inferences have already been drawn as to its origin—there being much to show that Europe has been longer inhabited by man than any other part of the globe.

We are now able to imagine a time succeeding the simian stage of ancestral man, when the human population of all Europe between the Baltic, the British Islands, Spain and Greece, was similar to the living Australoid stock in appearance, leading much the same life that is led by the Australian aborigines at the present day. We may surmise that from out of this Australoid stock arose the Negro, who populated a good deal of Western, Southern, and North-West Europe, leaving the traces of his dark eyes, dark skin colour and curly hair still behind him. Then there arose an altogether superior type from out of the Australoid of the north: the proto-Caucasian, not unlike in appearance to the Hamite, the Libyan of Africa, the Dravidian of Baluchistan, and the Ainu of Japan.

Somewhere in Asia, however, the Mongolian sub-species had come into being and advanced westwards. The hairy proto-Caucasian and the hairless and straight-haired Mongol mingled and produced a being not unlike the Aryan type. This tall-statured, prominent-nosed, smooth-skinned race ranged as mighty hunters right across Eurasia from Ireland to Alaska, and from Alaska over much of North America, where, however, it had been preceded by the more primitive Mongolian Eskimo, as well as by the Malayo-Mongolian races now dwelling in South America and in the Malay Archipelago.

But on the whole the population of Europe gradually settled down into two main types, the Nordic-European Types—tall, fair or brown-haired, grey or blue-eyed, with a tendency to hairiness of face and body in the male; and the Mediterranean race—of shorter stature, with black hair, brown eyes, a less pink- and white complexion, but with an equal tendency to hairiness. There remained also the
Inhabitants of British Isles

Mongolian element ever and again renewed from Asia, or from the far Eskimo or Samoyede North, which brought about smoother cheeks in the men, a greater hairlessness of body, and a rather more rugged type of face with projecting cheekbones. From the intermingling and east. The Spaniards are chiefly Iberian, with a strong flavour of the Moor, Arab, and Jew here and there, and have also been influenced by descendants of the fair-haired Nordic Goths in the north and north-west. The Italians are likewise mainly Iberian or Mediterranean,

of all these types have arisen the varied European peoples of to-day.

Our own islands have been continuously populated for perhaps 200,000 years, more or less. On the whole the British have preserved a longer skull than the German peoples of North and Central Europe. They belong, however, in the main to the Nordic type, though the Iberian or Mediterranean is well represented in Ireland, Western Scotland, Wales and Cornwall. The French are Iberian or Mediterranean in the west and south, but more Nordic in the north but they too have a strong Teutonic (Nordic) element in North Italy. Switzerland exhibits in almost marked contrast three types, the fair-haired Teuton, the dark-haired Mediterranean, and a somewhat complex type—the Alpine.

This Alpine type is met with a good deal in Southern Germany (Bavaria), for example, in Bohemia, above all amongst the Basques of the Pyrenees, and in Central France. It is rounder-headed and shorter-statured than the true Nordic type, and yet is not so markedly brunet as the pure Iberian.

THE HAIRY AINU OF NORTH JAPAN

Most of those present are women with imitation moustaches tattooed on the upper lip.
The Distribution of Man

It betrays here and there evidences of a very ancient Mongolian influence. Whether it be anything more than a hybrid race arising in mountain regions and developing peculiar characteristics due to mountain climbing, is still a moot question, but it cannot be called distinctly Mediterranean or Nordic.

In much of Germany there is another complication. The German-speaking population is for the most part “Nordic,” in so far as yellow, brown, or flaxen hair is concerned, and grey or blue eyes. But in head form it is markedly round as compared to the long skull of the Englishman or the Iberian. Perhaps this is due to ancient as well as modern Mongolian invasions, which have left behind the round skull of Central and Eastern Asia; or it may be due entirely to local developments and local specialisation. Many of the Slavie-speaking peoples of North and East Germany belong to the Nordic type. On the other hand, the older strain, especially that which is associated with Lithuanian speech, is quite distinct. It has the broad, rather prominent cheekbones of the Mongol, but the dark hair and brown eyes of the Mediterranean, and a much greater hairiness of body and face in the male than is associated with the Mongolian. In fact, it resembles strikingly that most interesting of stranded races, the hairy Ainu of North Japan, and possibly this Ainu race descended directly from the proto-Caucasian migrations which stretched once uninterruptedly from England to Japan across Europe and Asia.

Russia has been a great breeding-ground of peoples, no doubt owing to its extremely fertile black soil and absence of rugged mountains. In Russia you have still surviving and distinct side by side the Lithuanian or Ainu type and the tall, remarkably handsome Goth, who because he is long-headed and not short-headed like the Teuton, is strikingly like many Englishmen and Scotsmen in appearance (derived from an ancient long-headed Gothic ancestry through the Norsemen and the Angles). Then there is the Kalmuk, a Mongolian, with harsh features, straight hair, poor beard and hairless body, who comes straight from the Asiatic steppes; and finally there is a branch of the Mediterranean race sometimes called the Dinaric, differing chiefly from the average Iberian or Mediterranean type by its being of taller stature. This type attains a handsome development in the Albanian and some of the Slav peoples of the Balkan Peninsula. It was the dominant ancient type of Asia Minor, South Russia and North Persia.

In the Balkan Peninsula may be seen to-day descendents of the Goths—fair-haired, long-headed, handsome, English-like folk; of the round-headed Teutons (even though they may be speaking Slav languages); of the Hun and Tartar and other Mongolians, who in the historical period invaded and ravaged so much of Eastern Europe; of the afore-described Dinaric type; and of the Greek element. The Greeks, however, though they certainly offer a distinctive and characteristic profile in which there is hardly any dip at the base of the nose and in which the eyes are grey, though the hair may be brown or dark, are likewise very composite in origin.

If Europe has been a melting-pot, what are we to say about North America? Into it all the principal European types are now being poured, together with a few Asiatics and a considerable contingent of Negroes; while remarkably potent for their numbers are the 150,000 or 200,000 (for they are increasing) Amerindian aborigines. We seem to see in course of time all these diverse human types intermingling, and from out of them arising a Superman, nobler, handsomer, more intelligent, more god-like than has yet been produced in the Old World. H.H.J.
8. Ocean Currents and Tides

Movements of the Oceans—Salinity of Sea Water—System of Currents—Attractive Force of the Moon—Tidal Waves

Owing to the mobility of the waters of the oceans, they are capable of responding by movement to changes of temperature and salinity, to the forces set up by the circulation of the winds, and to the gravitational attraction of the moon and sun.

It is to these three sets of causes that the movements of the ocean waters are mainly due, Movements of Ocean Waters the first being responsible for the vertical circulation of the waters, the second for the superficial but gigantic eddies which constitute the great majority of the ocean currents, and the third for the tides which twice every day sweep over the surface of the oceans.

It was thought at first that ocean currents were primarily set up owing to the difference of temperature between the equatorial and polar regions. Such a difference, in the absence of interference from other causes, would induce a flow of the warmer and lighter surface waters from the Equator to the poles, and a compensatory flow of the colder and heavier deep waters from the poles to the Equator.

Just as in the case of the winds, the directions of movement would be deflected by the rotation of the earth, and by the arrangement of the land areas. There is little doubt that a vertical flow set up by convection in this way does occur, but it is so feeble and slow that it can have little effect on the more powerful currents known to exist.

The variation of density and temperature with depth was determined during the famous voyage of the Challenger, and the following figures were given by the late Sir John Murray, as the averages of observations at all latitudes for the specified depths:

<table>
<thead>
<tr>
<th>Depth</th>
<th>Mean Temp.</th>
<th>Mean Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>surface</td>
<td>variable</td>
<td>1.0252</td>
</tr>
<tr>
<td>100 fathoms</td>
<td>60-7° F.</td>
<td>1.0261</td>
</tr>
<tr>
<td>200</td>
<td>50-1° F.</td>
<td>1.0268</td>
</tr>
<tr>
<td>300</td>
<td>44-7° F.</td>
<td>1.0271</td>
</tr>
<tr>
<td>400</td>
<td>41-8° F.</td>
<td>1.0273</td>
</tr>
<tr>
<td>800</td>
<td>37-3° F.</td>
<td>1.0276</td>
</tr>
<tr>
<td>1,500</td>
<td>35-3° F.</td>
<td>1.0279</td>
</tr>
<tr>
<td>2,000</td>
<td>35-2° F.</td>
<td>1.0280</td>
</tr>
</tbody>
</table>

The dissolved salts in sea water have the following average composition:

<table>
<thead>
<tr>
<th>Salt</th>
<th>Parts per 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium chloride</td>
<td>27.213</td>
</tr>
<tr>
<td>Magnesium chloride</td>
<td>3.807</td>
</tr>
<tr>
<td>Magnesium sulphate</td>
<td>1.658</td>
</tr>
<tr>
<td>Calcium sulphate</td>
<td>1.260</td>
</tr>
<tr>
<td>Potassium sulphate</td>
<td>0.863</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.123</td>
</tr>
<tr>
<td>Magnesium bromide</td>
<td>0.076</td>
</tr>
<tr>
<td><strong>Total Salinity</strong></td>
<td><strong>35,000</strong></td>
</tr>
</tbody>
</table>

The salinity of the surface waters varies from place to place according to (1) rainfall and the Salinity inflow of rivers, which tend to freshen the water, and to (2) evaporation, which tends to increase the salinity. The highest salinity is found in the east of the Mediterranean and in the north of the Red Sea, where evaporation is high and the addition of fresh water from rivers and rainfall is low.
Surface currents flow into the Mediterranean, both from the Atlantic, through the Straits of Gibraltar, and from the Black Sea, through the Dardanelles; while underecurrents, which have a higher salinity than the surface waters, flow outwards from the Mediterranean (Fig. 1).

This circulation is maintained by the excessive evaporation over the Mediterranean, which lowers its surface and increases its salinity.

**How Circulation is Maintained**

The lighter and less salt water of the Atlantic flows in, and the heavy and more salt water of the Mediterranean sinks and flows outwards.

At the Bosphorus and the Dardanelles, the explanation is similar, for evaporation over the Black Sea is more than neutralised by the excessive inflow of fresh water from rivers and the consequent rise of level.

A similar interchange of water takes place between the highly salt Red Sea and the Indian Ocean, through the Strait of Bab-el-Mandeb; also between the comparatively fresh Baltic and the North Sea, through the Skager Rack. In all cases the surface flow is from waters of less salinity to those of higher salinity.

With the exception of tidal currents and those just described as due to changes of salinity, all the ocean currents are now attributed to the action of the winds. The surface waters down to a depth of between 50 and 100 fathoms circulate around the six great ocean areas, in approximately the same directions as the prevailing winds.

The six systems of currents referred to are those of the North and South Atlantic, the North and South Pacific, the Indian and the Southern (Antarctic) Oceans. If the Arctic Sea be considered as a separate ocean and not as an appendage of the North Atlantic, a seventh system should be added. In the tropical seas the currents pass generally from east to west, but in higher latitudes the direction is reversed and the waters move from west to east.

On each side of the Equator in the Atlantic are east to west currents driven by the trade winds, known as the **North and South Equatorial currents**. Between them is a feeble and irregular current which takes the opposite direction, called the **Counter Equatorial current**.

The South Equatorial current divides at Cape St. Roque in Brazil into the **Brazil current** flowing to the south-west, and into a north-easterly branch which enters the Caribbean Sea in company with the North Equatorial current. The Brazil current gradually comes under the influence of the westerly winds and is turned eastwards across the Atlantic, where it merges into the **Benguela current**.

The two currents which flow into the Caribbean Sea, divide at the West Indies, part passing into the Gulf of Mexico and part flowing towards the Atlantic States.

In the Gulf of Mexico the level of the water is relatively raised, and as evaporation is high, a warm saline current, well known as the **Gulf Stream**, passes swiftly (50 or more miles a day) through the Strait of Florida. Joining the outer current of the West Indies, it flows along the North American coast, gradually becoming wider, shallower and colder, until it meets the cold **Labrador current** south of the Gulf of St. Lawrence.

It was for long believed that the mild climate of Western Europe was maintained by an extension of the Gulf Stream across the Atlantic. Actually, both the climate and the **North**
Systems of Currents

Atlantic Drift, into which the Gulf Stream merges, are controlled by the prevailing westerly winds.

The slow North Atlantic Drift, which is very different from the powerful Gulf Stream, divides as it approaches Europe. A southern branch completes the North Atlantic eddy as the Canaries current, one northern branch continues past the British Islands to the Norwegian coast, and another flows northwards towards Greenland.

From the Arctic, cold currents flow southwards along the eastern coasts of Greenland and Labrador, and thus a subsidiary eddy is produced in the northern part of the North Atlantic. Thus, in the south of the North Atlantic, there is a clockwise circulation agreeing in direction with the winds of the anticyclonic region which there prevail; whereas, farther north, there is a subsidiary anti-clockwise circulation corresponding to the cyclonic systems of winds which is characteristic of such latitudes.

In the Pacific, the general rotatory circulation is very similar to that of the Atlantic. The North Equatorial current flows from east to west with the trade winds and is deflected by the Philippines, from which the water flows as the Japan Stream past the coasts of Japan.

This stream is analogous to the Gulf Stream, and, like the latter, it weakens and spreads out as a shallow drift known as the North Pacific Drift. Meeting the American coasts, the circulation is completed by the Californian and Mexican currents. Corresponding to the Labrador current, there is a cold Arctic current from the Behring Straits, which hags the eastern coast of Asia, and sets up a subsidiary anti-clockwise circulation in the extreme north.

In the South Pacific, the South Equatorial current (separated from its northern neighbor by a weak counter current) flows to the west, and the circulation is completed by the East Australian current, the Antarctic Drift and the Peru current. The cold Antarctic Drift passes completely round the Southern Ocean from west to east, and sends cold arms towards the western

shores of all the southern lands, helping to feed the Peru current, the Benguela current and the West Australian current.

In the Indian Ocean, the circulation is complete only in the southern half. As before, there is a South Equatorial current which turns to the south in two branches, one outside Madagascar and the other, the Mozambique current, through the Mozambique Channel, between Madagascar and the African mainland. Meeting with westerly winds and the Antarctic Drift, the rotation is completed by the West Australian current.

In the northern portion of the Indian Ocean, the currents change with the seasons owing to the force of the monsoons. While the north-east monsoon is blowing in the winter a current flows
Ocean Currents and Tides

to the west around the shores of India and Arabia, and is thus the equivalent of the normal North Equatorial currents. A weak counter current in the belt of calms separates it from the South Equatorial current, and completes the circulation in the northern part of the ocean (Figs. 2 and 3).

In the summer, however, when the south-west monsoon has developed, the currents are reversed. A current then flows toward the east around the shores of Arabia and India, and the circulation is completed by the South Equatorial current.

The periodical rising and falling of the waters set up by the attraction of the moon and sun twice in 25 hours, is referred to as the tide. Owing to the nearness of the moon, it is more than twice as powerful an agent in raising tides as the sun. Between the moon M and the centre of the earth E (Fig. 4), there is an attractive force a which is exactly balanced by the centrifugal force c (Fig. 5), due to the revolution of the earth and moon about their common centre of gravity G. At A, however, on the side of the earth facing the moon, the attraction a' is greater than the centrifugal force e', and the waters rise up. At B, on the opposite side, the attraction a'' is less than the centrifugal force e'', and the water is, so to speak, whirled outwards. In each case the tide-raising force is nearly the same, but on the near side it is due to an excess of attraction, while on the far side it is due to an excess of centrifugal force. In the positions C and D, the waters are drawn away and low tide results.

As the earth rotates, each meridian comes in turn beneath the positions of high and low tides twice a day. But as the moon is revolving about the centre of gravity G of the earth-moon system, in the same direction as the earth rotates, it is necessary for the earth to turn a little farther before it brings any meridian under the same position relative to the moon which it occupied on the previous day. Thus, on the average, the times of high tide are separated not by periods of 12 hours, but by 12 hours 25 minutes (Fig. 6).

The effect of the sun is similar to that of the moon, but, as already stated, it is less powerful. When the earth, sun, and moon fall into the same straight line, the tide raising forces of sun and moon help each other, and specially high and low or spring tides result (Fig. 7). When the moon and sun are at right angles with reference to the earth, the moon produces high tides in the positions where the sun tends to produce low tides. The tides are then less high and low than usually, and are called neap tides (Fig. 8).
Owing to the depth of the oceans and the distribution of land, the high tides do not swing round directly under the moon. The actual paths taken by the tides in the Atlantic and around the British Isles are shown in Figs. 9 and 10.

In the open ocean the difference in level between high and low tide is only a few feet. Near land, however, where the sea shallows, and particularly in funnel-shaped gulfs, the tidal wave is more heaped up, and tides of 20 or 30 feet are common. In the Bristol Channel, 42 feet is reached during spring tides, and in the Bay of Fundy the difference amounts to 70 feet.

In extreme cases, when the front of the advancing wave is strongly retarded by friction against the sea bottom, the upper part of the wave may break and move bodily forward. The front edge, advancing like a wall of tumbling waters, is known as a bore. In the Severn this sometimes reaches a height of 4 feet.

Tidal currents are set up by the tides, advancing and retreating alternately to and from the shore, when the tidal wave advances directly towards the land. When, however, the tide travels parallel to a coast, the currents also move along the coast. Generally the forward current is stronger than the backward current, and the ultimate consequence of tidal currents of this kind, which are well illustrated in the English Channel, is to drift sand and shingle in the direction of the advancing tide.

Along the coasts of the English Channel, groynes have been erected to restrain the drifting of shingle from west to east, and the importance of this movement may be visibly demonstrated by taking a walk along our southern shores wherever groynes are to be found.

A. H.
9. Climate and Weather


The atmospheric conditions from day to day at any place are referred to as the weather at that place. Climate is a term of broader significance, and is applied to the average atmospheric conditions, or the average weather, of any region during a defined season, or during the yearly succession of seasons.

The chief elements that enter into the make-up of weather and climate are:
(a) temperature, (b) humidity, including the various forms of moisture—fog, clouds, rain and snow—and (c) wind; including the various types of storms. The chief factors which control climate are solar heat, the inclination of the earth’s axis, the revolution of the earth about the sun, the rotation of the earth atmosphere depends primarily on the supply of heat from the sun. Although the earth is losing heat by conduction from its still hot interior and radiation into space, yet the escape of terrestrial heat is relatively so small that its effect on climate is negligible. Locally, the escape of heat by volcanic activity may influence weather for a time, but such effects are exceptional and irregular, and do not enter into a general discussion of climate. All the exogenetic activities of the earth, except the lunar tides, depend on the heat radiation, or insolation, received from the sun.

It is clear from the diagram (Fig. 1) that any given area receives more heat near the Equator than near the poles; that is to say, the heat income of any place depends primarily on its latitude.

Since the earth’s axis is inclined to the plane of its orbit at an angle of 23.5°, and since the direction of the axis does not vary during the annual revolution about the sun, it follows that the sun’s rays do not always fall vertically at the Equator (Fig. 2).

On December 21st the North Pole is turned away from the sun, the northern hemisphere receives less than its average supply of heat, and the southern hemisphere
The Seasons

more. The sun's rays then fall vertically over $23\frac{1}{2}^\circ$ S. latitude; summer begins in the south and winter in the north. On June 20th the North Pole points towards the sun and the solar radiation falls vertically over $23\frac{1}{2}^\circ$ N. latitude. Summer then begins in the north and winter in the south.

Between these two extremes lie the equinoxes, March 20th and September 22nd, when day and night are equal all over the earth and the sun's rays fall directly over the Equator. The seasons are thus determined by the inclination of the earth's axis and the revolution of the earth about the sun.

When the sun's radiation reaches the earth it impinges on gaseous, liquid and
solid matter, and in so far as it is absorbed, the ethereal vibrations are transformed into heat; that is, the molecular energy is increased and the temperature of the substance is raised. All solar radiation, however, is not absorbed; it may be reflected, or it may be transmitted, and in neither case is heat produced.

A good reflector, like silver, cannot be easily heated by absorption. Clouds, snow and water are good reflectors, and, therefore, the sun's rays are largely reflected by them back into space, and there is little acquisition of heat.

The chief gases of the atmosphere are good, indeed almost perfect, transmitters of radiant energy. They are warmed only very slowly by the exceedingly small amount which they retain as heat; practically all the sun's rays pass through a clear atmosphere without being reflected or absorbed. The land surface, however, is a very bad reflector and transmitter, and it therefore absorbs a high proportion of the radiation that falls upon it, and is rapidly warmed under sunshine.

In turn, the earth loses heat by radiation into space. The land surface, being a good absorber, is also a good radiator, and under a clear sky it rapidly loses at night the heat gained during the day. If, however, the night sky is overcast by clouds the land radiation is reflected back and the fall of temperature in the atmosphere between land and cloud is less than it would be in a corresponding thickness of air if the sky were clear.

Water vapour, carbon-dioxide, and dust particles in the atmosphere also aid in the flux of heat income and expenditure. They absorb heat during the day and radiate it, though more slowly, during the night. The actual temperature at any point below, at, or above the earth's surface thus represents a balance between heat gained and heat lost.

There are daily variations, from the high afternoon temperature to the low temperature of the early hours after midnight, and seasonal variations from the warmth of the summer to the cold of the winter. These extremes are, however, simply alternating oscillations about a mean temperature, which is determined by the balance of absorption from the sun and radiation from the earth.

It is important to notice that the moisture and dust particles of the air are largely confined to its lower levels, and further that they radiate the comparatively cold rays from the earth to a very much less extent than they absorb the solar rays. The lower atmosphere thus acts like a blanket, which gains and retains heat better than it loses it. For this reason high land, having a thinner and less effective blanket above it, loses heat more rapidly than low land, and the mean temperature is therefore lower the greater the altitude. Actually, the fall of temperature with elevation is about 1°F. in every 300 feet.

Since the land rapidly gains and loses heat, it is subject to wide extremes of temperature. The sea, on the contrary, is only able to gain or lose heat very slowly. Large bodies of water are thus conservative in their action and act as a regulator of temperature, cooling adjacent land in the summer and warming it during the winter. For this reason islands and coast lands have more or less equable temperatures, while the inland regions of continents are subject to wide limits from day to night and from summer to winter.

The temperature of the air is taken at observation stations by ordinary thermometers, which give the temperature only for the special periods at which they are read; by self-recording thermometers, or thermographs, which supply a complete record of the temperature.
changes during any given time; and by maximum and minimum thermometers, which register respectively the highest and lowest temperatures of the day.

From large numbers of observations at any one place, the mean temperature of the air for any day, month, season, or year can be calculated. The average of thirty or forty yearly means gives a reliable record of the mean temperature of any particular place.

It is on such means and on the limits between which they vary that many of the operations of gardening and farming are based. The yearly variation of minimum temperatures is a particularly useful item of climatic data, and the importance to the farmer of knowing, for example, when frosts are likely to end in the spring, or to begin in the autumn, is obvious.

Observations of these kinds are now made in all parts of the world, and for comparison they are all reduced to sea-level values; that is, 1° F. is added for every 300 feet of the altitude of the station. When all the data so obtained are laid down on a map, it is customary to show the distribution of temperature by drawing lines through all places with the same mean temperature.

Such lines are called isotherms, and isothermal charts are prepared generally for monthly means, but also for seasonal and yearly means. Examples of mean January and July isotherms for the whole earth are shown in Figs. 3 and 4 (p. 169).

It will be noticed that isothermal lines do not run exactly parallel to the Equator. This ideal case is interfered with by many factors, notably the distribution of land and sea, the altitude of the land, and the circulation of the atmosphere as wind. It should be noticed that while the seasonal variation of the tropics is low, there is a considerable daily variation of temperature.

The daily variation tends to decrease as higher latitudes are approached and the seasonal variation becomes more marked. At the poles the extremes are reached with their "six months' day and six months' night."

Since the atmosphere is subject to periodically changing temperatures, it will be clear that the primary effect of this is to bring about a corresponding periodic circulation of the atmosphere. Air which is being warmed expands, becomes lighter, and rises. Air which is being cooled contracts, becomes heavier, and tends to creep along under the warmer currents of rising air. For such reasons the pressure of the air varies from place to place and from time to time.

The average pressure of the atmosphere on the earth's surface is 14.7 lb. to the square inch, a pressure equal to that of a column of mercury 30 inches or 760 millimetres high, or to a column of water 34 feet high.

The barometer is the instrument by which atmospheric pressure is measured, and it is simply a column of mercury in a vertical glass tube closed at the upper end and immersed in a basin of mercury at the lower end. On the surface of the mercury in the basin the pressure of the atmosphere is exactly balanced by that of the mercury column, and the height of the latter in inches or millimetres affords an accurate measure of the atmospheric pressure at any time. Obviously this pressure must decrease with altitude above sea level. The air becomes less and less dense as we ascend above sea level, and hence the pressure does not fall off uniformly; successive surfaces of equal pressure (isobaric surfaces) are separated by greater and greater distances as the altitude is increased.

Taking density changes and temperature changes into consideration, the falling off in pressure is found to be, on the average, as follows:
Plants are unable to inhabit a region whose climate is antagonistic to their growth. There are two types of such regions—the dry desert, which lacks sufficient moisture, and the cold desert, which lacks sufficient warmth.

<table>
<thead>
<tr>
<th>Pressure in inches of mercury</th>
<th>Altitude in feet above sea level</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>29</td>
<td>910</td>
</tr>
<tr>
<td>28</td>
<td>1,850</td>
</tr>
<tr>
<td>27</td>
<td>2,820</td>
</tr>
<tr>
<td>26</td>
<td>3,820</td>
</tr>
<tr>
<td>25</td>
<td>4,850</td>
</tr>
<tr>
<td>20</td>
<td>10,550</td>
</tr>
<tr>
<td>impereceptible</td>
<td>30 miles</td>
</tr>
<tr>
<td></td>
<td>50 miles</td>
</tr>
</tbody>
</table>

If the air were of uniform density at all heights up to its outer limit, it would be only about five miles thick. Actually, the height is even greater than the 50 miles cited above, for meteorites become visible at twice that height at least, though at 100 miles the tenuity of the air must be that of a very good laboratory vacuum.

As in the case of temperature readings, so barometer readings, taken in various parts of the world by mercurial, aneroid, and self-recording barometers, are reduced to their sea-level equivalents for regional comparison. The distribution of pressure is then shown on charts by drawing lines through all places with the same pressure. Such lines are known as isobars; a mean isobar can be drawn for monthly, seasonal, and yearly periods. Mean isobars for January and July are shown in the charts, Figs. 5 and 6, on p. 175.

Since temperature is highest near the Equator, or more strictly at the "heat" Equator, according to the position of the sun, it will be clear that in the tropics the air rises and the pressure is uniformly low. The rising air, when it reaches a certain altitude, flows northwards and southwards towards the poles, with the...
result that in higher latitudes the pressure is increased, and a downward inflow of air begins towards the Equator to complete the circulation. The earth’s rotation, however, complicates this simple system of convection currents (Fig. 7, p. 174).

One of the fundamental generalisations of meteorology, which we need not stop here to prove, is Ferral’s law, which states that every body moving on the surface of the earth tends to be deflected to the right in the northern hemisphere, and to the left in the southern hemisphere, because of the earth’s rotation from west to east.

Any section of the northerly circulation of air currents is thus deflected towards the right in the northern hemisphere. The actual result is that the upper poleward moving currents are turned to the east, and the lower currents, moving along the earth’s surface towards the Equator, are turned to the west. Thus in the northern hemisphere there is a regular wind blowing towards the Equator from the north-east to the south-west, and in the southern hemisphere there are similar winds blowing regularly towards the Equator from the south-east to the north-west. These winds are respectively the north-east and south-east trade winds (Fig. 8, p. 174).

The upper currents blow prevailing from the west in temperate as well as tropical latitudes. The air ascends within latitudes 25° or 30° N. and S., but between 30° or 35° the conditions become critical. Centripetal force here overcomes the effect of temperature, and pulls the air currents back towards the surface. Beyond 35° N. and S. the pre-
vailing winds are from the west near the surface as well as in the upper atmosphere. In the polar regions the planetary circulation is less well known, for it is controlled largely by the distribution of land and sea and by the great ice caps which surround the poles. The trade wind circulation does not extend beyond a belt 35° north and south of the Equator. Between the two belts lie the doldrums or equatorial calms. Winds are light and variable, the air is sultry, the sky is often cloudy, and rains are frequent.

On the outer margin of the trade wind area the pressure is high. On one side lie the prevailing westerly winds of the temperate zones; on the other the trade winds of the tropics. The transition belts are therefore characterised by light and variable winds and occasional calms.

They are known as the horse latitudes or tropical calms, but in contrast to the wet and sultry doldrums, the weather is clear and fresh. Eddies in the descending currents of air are formed wherever the downward streams are specially strong, the wind circulation clockwise about the points of maximum pressure in the northern hemisphere, and in the opposite, anti-clockwise direction, in the southern hemisphere. Such systems of winds are called anticyclones. They tend to travel from west to east, in which direction they are drawn out, so that they constitute flat oval circulating systems. The westerly winds of the temperate regions are “prevailing” but by no means constant. They are frequently interrupted by storms, especially in the winter.

The varying directions of the winds in these latitudes are due to the formation of eddies, which may be of the anticyclone type as described above; or the cyclone type, within which pressure is low, and the air ascends, circulating anti-clockwise in the northern hemisphere.
Cyclones and Anticyclones

Fig. 5.—JANUARY ISOBARS

and clockwise in the southern hemisphere.

Cyclones and anticyclones are eddy-like systems which are very broad laterally but shallow vertically. They must be carefully distinguished from tornadoes and waterspouts, which are violent local eddies with extremely rapid circulation and possessing a pencil-like form in contrast to the plate-like form of cyclonic wind systems.

The direction of the wind in relation to the distribution of pressure is given by Ballot's law, which may be expressed as follows: Standing in the northern hemisphere with your back to the wind, the barometer will be lower on the left than on the right. In the southern

Fig. 6.—JULY ISOBARS

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hemisphere the opposite is the case: Standing with your back to the wind, the barometer will be lower on the right than on the left. It follows that the wind assumes a direction nearly tangential to the isobars rather than one passing directly from high pressures to low.

In a case where the isobars are straight, the direction of the wind lies between those of the arrows A and B, where A is parallel to the isobars and B is inclined at 45°. When the isobars are curved, the same relations hold as indicated in the adjoining diagrams, which illustrate cyclonic and anticyclonic types of isobars (Figs. 10, 11 and 12).

A cyclone is represented by closed isobars around a low-pressure centre, with circulating winds which tend to curve from the outer high-pressure region to the inner low-pressure region. An anticyclone is represented by closed isobars around a high-pressure centre, with circulating winds which tend to curve outwards from the inner high-pressure region to the outer low-pressure region. The directions followed by these circulating winds may be tabulated thus:

<table>
<thead>
<tr>
<th>Hemisphere</th>
<th>Cyclonic</th>
<th>Anticyclonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Hemisphere</td>
<td>Anticlockwise</td>
<td>Clockwise</td>
</tr>
<tr>
<td>Southern Hemisphere</td>
<td>Clockwise</td>
<td>Anticlockwise</td>
</tr>
</tbody>
</table>

In accordance with the planetary circulation of the winds, cyclonic and anticyclonic systems of winds pass round the world from west to east in both hemispheres. They are particularly numerous and strong between latitudes 50° and 60°, and since in the northern hemisphere these latitudes pass respectively through the Scilly and Shetland Islands, it is clear that the British Islands lie in a belt characterised by a maximum variability of the winds.

It will be clear from the diagram (Fig. 13) of a northern cyclonic system, that the winds in front (i.e. on the east) blow from south to north, and therefore draw warm air northwards. At the back of the cyclone (i.e. on the west) the winds blow from the direction of the Pole, bringing a "cold wave" from higher to lower latitudes.

On the east of a cyclone the temperature is abnormally high, air tends to rise, and the pressure is low. On the west, the temperature is abnormally low, air is heavy and tends to sink, and the pressure is high. This is consistent with the fact that cyclonic systems are generally drawn out along an east-west axis, moving from high to low-pressure regions, and therefore from west to east.

Along the northern shores of the Mediterranean cyclonic storms carry before them a hot, parching, dry wind which blows from the Sahara.

In southern Italy it is known as the *sirocco*, and this name is sometimes given to all warm cyclonic indraughts. Farther north it becomes charged with moisture,
The Monsoons

and consequently sultry and oppressive. In Spain the sirocco is called the leveche, and in Madeira the leste.

In Egypt cyclonic systems only occur when the equatorial belt moves farthest to the south in March. In the southern hemisphere sirocco winds come from the north, such as the brickfielders of Australia, and the zonda of the Argentine.

A peculiar variety of the warm winds set up by the indraught attending cyclonic disturbance is the föhn, a warm dry wind which descends northwards through the valleys of the Alps. Although it comes from the cold upland regions of the Central Alps, the descent is accompanied by a compression which raises the temperature, and since the moisture is precipitated very largely on the southern slopes of the mountains, the wind is dry. Violent floods frequently result from the melting of the snow over which the föhn passes.

A similar wind is the chinook of Alberta, which descends from the Rockies to the Canadian plain.

The cold wind which follows a cyclonic system comes to us chiefly from the north-east, since the waters on the north-west are mild compared with the cold lands of northern Europe. Unseasonable cold waves and excessive frosts are generally due to north-eastern indraughts of this character.

The mistral in the valley of the Rhône, and the bora on the coast of the Adriatic, are cold winds which descend from the Alps in the rear of cyclones. These examples of special winds are, however, dependent on the distribution of land and sea. The bora owes its abnormal cold temperature to rapid cooling over a high mountain or plateau region.

The differences in temperature conditions between land and sea surfaces have already been mentioned. The lands of the temperate zones are alternately warmer and colder than the surrounding seas in the course of a year. The warm lands of the summer cause the barometric pressure to be low and cool winds flow inwards. The cold lands of the winter raise the pressure and cold winds flow outwards. The winds thus set up are called continental monsoons.

It is in Asia that the conditions for monsoons alternate most strikingly. Central Asia contains the greatest mountain systems and the highest plateaus of the world; and to the south of this elevated region lie India, Burma, and China, which would normally be included in the belt of the north-east trades. In the winter the extreme cold of Siberia and Central Asia gives rise to an outflowing monsoon which blows from the north and north-east over India and China, thus strengthening the planetary trade winds.

Bringing cold dry air from the lands, the winter monsoon controls the rainless season. However, as the sun moves northwards again, the continent is gradually heated up, until it becomes a region of excessively high temperature. The pressure therefore falls, the monsoons weaken and blow from the east and then from the south.

On account of the persistence of the trade winds, however, the actual reversal of the monsoon lags behind the arrival of the hot season, and consequently there is for a time, especially in India, a period of intense heat accompanied by dry winds. This lasts from February to May. From then, however, till the end of September the monsoons are entirely reversed, bring much moisture
Climate and Weather

from the sea, and control the rainy season.

The direction of the monsoons is from the south-west over much of India, becoming southerly and south-easterly in the region of the Ganges delta, in Burma and China, and even easterly in Japan and Korea.

Besides the seasonal winds due to heating and cooling of the lands on a large scale, there are land and sea breezes set up by daily contrasts of temperature. After sunset the land is cooled more quickly than adjacent bodies of water; while after sunrise the land recovers its heat and rapidly overtakes the local seaward temperature.

In littoral and island regions there is therefore a sea breeze in the morning bringing an inflow of cool air from the sea. In the late afternoon it dies away, and towards evening a land breeze springs up carrying an outflow of cold air to the sea.

It is in the tropics that these breezes are chiefly felt. Farther north, the seasonal monsoons and the variable cyclonic systems of the prevailing westerlies generally succeed in masking the minor diurnal changes. Sea breezes in the tropics are pure and healthy, and prevent the high temperatures which obtain inland. Land breezes, on the contrary, frequently arise in malarial swamps, and are laden with unhealthy influenzes.

Other diurnal winds arise on account of the unevenness of the land surfaces. Valley breezes blowing down-stream at night, and mountain breezes blowing up the slopes during the day are the chief examples of this class.

If A B C represents a slope, it will be clear that during the day the surface air is warmed by insolation, and C becomes warmer than C', a point at the same altitude in the open atmosphere. The air at C, therefore, rises, for the whole system is in a delicate state of balance to begin with. Similar conditions apply at B and B', and thus air at B moves up to C and there develops an outdraught up the slope (Fig. 14).

At night the reverse phenomemon takes place, for the air on the higher slopes is more rapidly cooled by radiation, and an outdraught of air moves from the mountains down the valleys.

All the winds so far described draw their energy from solar heat and the earth's rotation. Tidal breezes set up by the moon's attraction are sometimes said to occur, but they are negligibly faint and only serve to indicate that the moon has practically no control over weather and climate. Winds due to volcanic outbursts, landslides, and avalanches sometimes occur, but except for temporary and local effects they are of trifling importance.

To sum up, the winds may be classified as follows:

<table>
<thead>
<tr>
<th>Name of Wind</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planetary, including</td>
<td>Permanent, but</td>
</tr>
<tr>
<td>the &quot;trades,&quot; and</td>
<td>migrating annually with</td>
</tr>
<tr>
<td>prevailing westerlies</td>
<td>the heat equator, within</td>
</tr>
<tr>
<td>Continental or</td>
<td>northerly and southerly</td>
</tr>
<tr>
<td>seasonal Monsoons</td>
<td>limits.</td>
</tr>
<tr>
<td>Land and Sea Breezes</td>
<td>Annual</td>
</tr>
<tr>
<td>Mountain and Valley Breezes</td>
<td>Diurnal</td>
</tr>
<tr>
<td>Cylonic</td>
<td>Diurnal</td>
</tr>
<tr>
<td>Anticyclonic</td>
<td>Irregular</td>
</tr>
<tr>
<td>Tidal breezes (?)</td>
<td>Semi-diurnal</td>
</tr>
<tr>
<td>Volcanic blasts</td>
<td>Accidental</td>
</tr>
<tr>
<td>Avalanche</td>
<td>and</td>
</tr>
<tr>
<td>Landslide</td>
<td>irregular</td>
</tr>
</tbody>
</table>

We may now pass on to consider the moisture of the atmosphere and its relation to weather and climate. The circulation of moisture demands a consideration of evaporation, of the distribution of the vapour so produced, and
Moisture of Atmosphere

of its condensation as cloud, fog, dew, rain, frost, snow, or hail.

The evaporation of water requires the expenditure of a considerable amount of energy, which does not appear in a rise of temperature. Water vapour at 60° F. contains more molecular potential energy than water at the same temperature which exists in the liquid state, and the relative proportion of each depends on the supply of energy.

After a rainstorm the sun’s rays are occupied in drying the land, and until this is done the temperature does not appreciably rise. Similarly over the oceans, solar energy is expended more in evaporating the surface-waters than in raising their temperature.

The quantity of vapour which the air can hold depends on its temperature, and for each temperature there is a definite pressure to which the vapour can rise, but which it cannot exceed. When the air contains the greatest amount of vapour which it can hold, it is said to be saturated. If the temperature falls, some of the vapour will be condensed; and if it rises, either the air will then be unsaturated, or more vapour will be formed by evaporation till the point of saturation is again reached.

At ordinary temperatures the capacity of air for vapour is doubled if the temperature rises by 18° F., but it should be noticed that the increase of capacity is greater at high temperatures than for a corresponding rise at low temperatures.

Since water vapour is the lightest of the common gases of the atmosphere, moist air is lighter than an equal volume of dry air. When water evaporates into dry or unsaturated air, the expansive force of the latter is, therefore, increased.

Humidity is the term given to the state of the air with reference to its vapour content. The humidity is high or low according as the air is damp or dry. Over the oceans the air has a high humidity, approaching saturation in the doldrums, but in desert regions the humidity is low.

The human body is very sensitive to changes of humidity, for the reason that it attempts to maintain a constant temperature of 98° F. If it is cold and dry, the protection of clothing is generally enough to maintain comfort. If it is cold and damp, the air withdraws more heat from the body than before, because wet air and wet clothing are better conductors of heat than dry. Dry cold is brae, but damp cold is penetrating and chilling.

If it is hot and dry, the skin keeps cool by evaporation of moisture from its surface, and if the conditions are extreme the skin becomes parched and burned. When the air is hot and damp, evaporation cannot proceed and the weather is oppressive and sultry.

The humidity of the air is measured in two ways. The absolute humidity is the amount of vapour actually present, and the relative humidity is the ratio of the absolute humidity to the humidity corresponding to complete saturation at that temperature. The relative humidity falls as the temperature rises and vice versa. Over deserts the relative humidity may be as low as 10 per cent., while over the oceans it frequently exceeds 90 per cent.

If the temperature falls, a point is reached at which the humidity of the air just suffices to produce saturation. This temperature is called the Dew point, and at lower temperatures the air becomes over-saturated and a certain amount of vapour is condensed as dew.

The dew point is measured by an instrument termed a hygrometer. There are various forms of hygrometers, but the principle applied in each case is the same. A surface, generally of polished silver, is gradually cooled down until dew just appears. The temperature of
Climate and Weather

the surface, which is that of the required dew point, is then measured as accurately as possible.

The formation of dew is well illustrated by the deposit of moisture which forms on the outer surface of a glass of ice-cold water in a warm room. Dew is not the result of a fine rain, but is formed by the condensation of atmospheric moisture on substances which have been cooled sufficiently by radiation.

Good radiators, therefore, gather more dew than bad ones, for their temperature falls more rapidly. Grass and painted railings may be heavily charged with dew when unpainted metal surfaces and rocks show little or no trace of moisture. A clear sky and a calm but damp atmosphere provide the most effective conditions for copious deposition of dew.

Clouds passing overhead prevent radiation and thus prevent cooling and dew formation.

Gardeners apply this principle in protecting delicate plants from cold and nipping by frost. The plants are sometimes covered with matting, or a smoky fire may be made, so that a protecting layer of smoke passes slowly over them.

White or hoar frost is of the same nature as dew, but is produced at temperatures below 32°F., the freezing point of water. Ordinary frost is due to the freezing of water already in the subsoil, and may or may not be accompanied by hoar frost according to the conditions controlling radiation.

If a large mass of air is cooled down to the saturation point, tiny spherical drops condense about suitable nuclei and a mist is formed. If the mist is formed up in the air it is called a cloud.

When nearly saturated air rises, it may cool by expansion, or it may meet with a cold upper current; in each case a cloud will be formed if the dew point is reached.

The nuclei about which cloud particles form must be of extreme fineness, for the particles themselves may be only 1/4000th of an inch in diameter, and no perceptible sediment ever falls with rain except in smoky regions. It is probable that electrically charged atoms serve as nuclei, though the fine “dust” which is responsible for the colours of the sky is generally invoked as the effective cause of condensation.

Clouds formed below 32°F. consist of minute spicules of ice, a fact known from direct observation on lofty clouds in mountain regions and from balloons, and also inferred from the nature of the halos and coronas which are produced by the action of clouds on sunlight. As the size of cloud particles increase by

<table>
<thead>
<tr>
<th>Types of Clouds</th>
<th>Characteristics</th>
<th>Average limits of height in miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cirrus</td>
<td>Slender, fibrous, feathery or curling forms.</td>
<td>5-10</td>
</tr>
<tr>
<td>2. Cirrostratus</td>
<td>Cirrus forms associated with long parallel series of straight or gently curved layers of cloud. They are often rippled or striated and, as a result of perspective, appear to converge towards the horizon.</td>
<td>3-6</td>
</tr>
<tr>
<td>3. CirroCumulus</td>
<td>Broken up foam-like clouds, often giving rise to the well-known “mackerel sky.” They are frequently associated with long streamers and trails of cirrus clouds.</td>
<td>i-2</td>
</tr>
<tr>
<td>4. Cumulus</td>
<td>Heaped up massive clouds like bulky masses of cotton wool.</td>
<td>1-2</td>
</tr>
<tr>
<td>5. StratoCumulus</td>
<td>Cumulus clouds which at higher altitudes have spread out laterally into flat expanses with sharply-cut borders.</td>
<td>i-1</td>
</tr>
<tr>
<td>6. CumuloNimbus</td>
<td>Large cumulous clouds having a dark and gloomy aspect; often somewhat anvil shaped and associated with thunderstorms.</td>
<td>0-1</td>
</tr>
<tr>
<td>7. Stratus</td>
<td>Includes fogs, and low-lying sheets of foggy cloud generally.</td>
<td>0-1</td>
</tr>
<tr>
<td>8. Nimbus</td>
<td>Extensive overcasting clouds from which rain or snow is falling.</td>
<td>0-1</td>
</tr>
</tbody>
</table>
Rainfall

continued condensation, they overcome the buoyancy of upward currents and begin to fall as snow, rain, or hail according to the temperature conditions through which they pass.

Clouds frequently form over mountainous islands and peninsulas during the day, for the damp sea breezes are turned upwards by the slope of the land, and if the air should rise sufficiently it may become cloudy on account of the cooling which results from expansion.

For a similar reason mountain ranges are often blanketed with clouds, while lakes may lie under a clear sky. Ascending air currents always tend to cloud formation, whereas descending currents favour a clear sky.

Cloud forms are classified as shown in the table on the opposite page.

All forms of precipitation of moisture from the atmosphere—rain, sleet, snow, and hail—are grouped together under the general term of rainfall.

Raindrops are limited in size because they tend to break up as their falling velocity increases. The larger the drop the lower is the maximum velocity at which it is able to fall. If at any stage in the history of a raindrop the temperature of the layer through which it is falling is below freezing point, the drop constitutes the nucleus of a hailstone. Once formed, a hailstone may grow by further condensation and freezing on its own surface; and it is significant that while raindrops never exceed a certain size, which, except in strong winds, is incapable of doing much damage, yet hailstones may reach considerable dimensions capable of serious destruction.

The formation of snow flakes is still an unsolved problem. In the polar regions rainfall is represented by fine ice crystals, and snow may represent the slow crystallisation of condensing moisture on a nucleus of one of these crystals in fairly quiet atmospheric conditions. Often snow crystals grow out from a single centre in the most beautifully symmetrical hexagonal designs.

Sleet is generally partially melted snow, but it may be partially frozen rain.

Rainfall is measured by exposing a vertical cylindrical vessel, called a rain gauge, fitted with a measuring tube of smaller sectional area, by means of which the rainfall in a given time at a given place is accurately recorded in inches (see Fig. 17).

The annual deposit of dew on our islands averages about 1 1/2 inches of rain. Ten inches or a foot of snow is generally taken as the equivalent of an inch of rain, but snow should be melted before measuring.

Since rainfall is produced by condensation, and the latter is brought about either by the expansion and cooling of rising convectional currents of air, or by the meeting of damp with cold currents, it is clear that rainfall is largely conditioned by the winds.

In the equatorial belt of the doldrums there is a constant upward movement of warm damp air, leading to the production of clouds each day, with afternoon rain showers or even thunderstorms. The annual equatorial rainfall reaches about 100 inches. By night the clouds dissolve away and the following day begins with a clear sky. This latter phenomenon demands some explanation. At night the air is cooled, and one would suppose that cloud and rain precipitation should be increased. However, since the air is cooled it does not rise so high, and moreover the pressure is somewhat higher, which further prevents expansion; and hence elevations at which clouds would form may be never reached, and clouds which have already formed may sink and be dissipated.

In the trade wind belt, rains are light over the oceans because the temperature
Climate and Weather

rises as the winds progress Equatorwards. If, however, the winds impinge on a mountainous coast or island, the air ascends and expands, and a heavy tropical rainfall results.

For these reasons the windward slopes of islands and continents (e.g. the Antilles, East Africa, and Brazil) are well watered and heavily clothed with vegetation. The leeward sides, however, are generally dry and barren (e.g. Peru, Chili, and parts of South-West Africa).

Over the lands, the trade winds take up all the moisture they can get and produce barren and arid deserts, such as the Sahara and Kalahari, the deserts of Arabia and Persia, and those of Australia. In North and South America the great westerly ranges prevent the attainment of extreme desert conditions by drawing from the winds a plentiful rainfall on the east, which flows Atlanticwards through lands which otherwise would be unwatered.

In the horse latitudes the air currents descend and the pressure is high, with the consequence that the air becomes dry and clear and rains are few and local only.

The zone of the irregular but prevailing westerly winds are subject to eylonie eddies in which cloud sheets and rain storms are frequent. Over the oceans and on western coasts the violence of wind and rain is greatest in the winter, but within the continents damp air is drawn in from the sea more abundantly during the summer, and rainfall is, therefore, most abundant during that season.

Towards the poles snow tends to fall instead of rain, but the actual amount of precipitation is comparatively low, being usually less than 15 inches. In an equatorial thunderstorm a mass of saturated air, in cooling from 90° F. to 80° F., would supply twenty times as much precipitation as a polar storm in which the fall of temperature was from 0° to -10° F.

Following the passage of the sun, the equatorial belt of constant rainfall migrates to the north in September (A B in the diagram, Fig. 15). By December it has returned to the Equator proper, and the belt B C experiences a wet season. In March the region C D south of the Equator has its rainy season, and in June the belt of rains is back to the Equator. It thus happens that the equatorial climate (in the belt B C) is characterised by a double series of rains, falling around June and December respectively, while on either side there are tropical belts having only one rainy season.

The annual flooding of the Nile is an interesting consequence of the rainy season of Abyssinia. In India the monsoon winds accentuate the contrast of wet and dry seasons. The greatest rainfall of the world is found on the slopes of the Himalayas (rising to as much as 480 in.), and while the south-west or summer monsoons are blowing from June to September, nearly all of this is precipitated, the remaining months, which are controlled by the north-east or winter monsoons, being dry.

The high pressure and dry belt of the sub-tropical areas is also subject to migration. If B C represents its mean position, then it moves northwards in September, and countries like those of the Mediterranean and California then have their dry season. Climates controlled by this feature are said to be of the Mediterranean type, having rain in winter and drought in summer. By March the dry high-pressure belt has migrated to C D, and countries like the south of Australia and the south of South Africa and South America then have a dry season. In lower latitudes than C D, the trade winds are the controlling feature (Fig. 16).

So far, thunderstorms have not been mentioned, and these deserve some atten-
Thunderstorms and Simooms

Thunderstorms seem to depend on a convective overturning of the atmosphere. They occur in all latitudes, more particularly in the eastern and south-eastern parts of cyclonic systems, in the summer season, and particularly in spells of hot weather and during or after the hottest part of the day.

Strong upward currents of warm air give rise to heavy cumulo-nimbus or thunder clouds, from the base of which cool air flows downwards (the thunder squall) in front of the rain. The upward inflow of moist air tends in some way as yet not thoroughly understood, but doubtless depending on friction, to the accumulation of atmospheric electricity.

This is discharged as lightning, which generally flashes from cloud to cloud, but sometimes strikes down to earth, choosing elevated points such as trees and churches. The lightning is due to violent vibrations set up in the ether, and the accompanying thunder results from the vibrations set up by the discharge in the air itself.

Thunderstorms generally pass rapidly eastwards in the direction of cyclonic movement, leaving clear and cool conditions in their rear. In the doldrums, where the air is constantly turning upwards, thunderstorms are common in the late afternoon.

More violent, however, are those of tropical Africa, where they may be accompanied by local whirlwinds of great energy called tornadoes, which are set up locally in or behind the furious squall which blows outwards from the underside of the clouds (Fig. 18).

Of similar origin are the dust storms and simooms of the Sahara and Arabia, where the squall is found, even though the region is dry and no rain or thunder accompanies the "sandstorm." Cloud-bursts are excessively violent thunderstorms, and waterspouts are the result of tornado action over the sea. It should be noticed that the water of waterspouts is not drawn up from the sea to any great extent. The greater part of it is a violent whirl of rainwater.

Climate and the distribution of vegetation are very closely connected (see "The Distribution of Plants").

The following table gives the chief types of vegetative regions in relation to rainfall and temperature:
Climate and Weather

<table>
<thead>
<tr>
<th>Temperature and Latitude</th>
<th>Abundant</th>
<th>Moderate</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Tropical</td>
<td>Forest and Jungle Equatorial belt and Monsoon areas.</td>
<td>Grass Savanna areas, e.g. Highlands of Brazil and South Africa.</td>
<td>Dry Deserts of the Trade Wind areas.</td>
</tr>
<tr>
<td>Temperate</td>
<td>Forest With corn and wheat, e.g. W. Europe</td>
<td>Grass Steppe areas, S.W. Asia</td>
<td>Cold Deserts Tundra of N. Asia. Barren Lands of N. America. Greenland, Antarctica, etc.</td>
</tr>
<tr>
<td>Cold Polar</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We will conclude by passing in review the world’s chief climatic regions.

The torrid zone is defined by latitudes 23 1/2° north and south of the Equator, or by the isotherms corresponding to about 70° F. The equatorial belt of the tropics is marked by a double rainy season corresponding to the northward and southward passage of the sun, whereas on either side of this belt there is only one rainy season.

The climate of the Indian monsoon region stands alone in having naturally three distinct seasons: a cold season from October to January, when the strengthened trade winds are blowing; a hot dry season from February to May, before the winds weaken and reverse; and a hot rainy season from June to September, when the moist monsoon from the south and south-west is blowing.

On each side of the tropics are vast stretches of desert, corresponding to the dry trade wind regions and the high pressure belts. The Sahara, in the northern hemisphere, and central Australia, in the southern hemisphere, are the most notable examples. In the trade wind latitudes, western coasts tend to be dry and barren, while eastern coasts are well watered and their temperature is modified by the sea breezes.

The temperate zones differ in the northern and southern hemispheres in accordance with the distribution of land and sea. In the south the oceans predominate, and conditions are more equable than in the north, where the land is broad and extensive, leading to climatic extremes within the continents.

Between the temperate and subtropical belts lie a number of areas, the climate of which is characterised as Mediterranean. These areas, which include the lands around the Mediterranean, the southern coasts of Australia and South Africa, California and parts of Chili, are characterised by the dryness and warmth of the trade winds during the summer, and the moisture and storms of the westerly winds during the winter. They partake of the features of both sub-tropical and temperate climate, according to the sun’s position.

North and south of the temperate zones lie the frigid zones of the Arctic and Antarctic regions. Here persistent low temperature is the prevailing characteristic. The annual precipitation rarely exceeds the equivalent of 15 inches of rainfall.

A. H.
10. Trade and Transportation

Commerce and Existence—Production of Raw Materials—Manufacture and Transportation—Animal Transport—Roads and Railways—Inland Waterways—Trans-Isthmian Canals—Ocean Transportation

HUMAN progress is largely the result of man's control of Nature. Man has become the master of the world he lives in, because he has learned by long ages of patient experiment and research how best to utilise for his own needs the gifts of Nature, and because he has discovered by age-long experience how to overcome natural forces or bend them to his will.

Man is to a great extent limited by his surroundings. Man's relation to his environment is responsible for the "struggle for existence," whose purpose seems to be the "survival of the fittest." One great difference, however, between primitive and civilised peoples is that the former are the greater slaves to environment, while the latter have risen so far superior to it that they have taken advantage of their natural situation and surroundings to build up civilisation and culture. Among both primitive and civilised peoples the struggle for existence is a fierce one, though waged with different weapons and by different methods. But the fittest that survive among primitive peoples are very different from the fittest that dominate advanced races. "Fitness," in the one case, stands for brute strength; in the other for the triumph of intellect.

Commerce is merely one of man's expedients in the struggle for existence. In all phases of the struggle it is more or less dependent upon natural conditions. Differences in situation, surface relief, soil, climate, and so forth, involve differences in natural resources, in means of communication, in occupations and products, and in national character and culture.

Few countries, if any, possess all the natural resources needed by their inhabitants. Certain regions can produce certain commodities far more cheaply and of better quality than most other regions can produce them. Any country which undertakes to remain independent of the rest of the world for supplies, and elects to produce everything it needs, will be obliged to reduce its necessities to a narrow limit, which will always be a hindrance to progress and culture. Hence arises the necessity for the wide interchange of products among the nations which has resulted in that most complex of human relationships—trade. The trade of any region depends primarily upon its natural resources, its world-position, and the character of its inhabitants. If the people are enterprising and skilled in manufactures, local resources are utilised in scientific fashion with the maximum productive result. If the region be conveniently situated for trade with other countries there is no waste with excess of production, but only wealth and a source of further power and energy.

The greatest traders and the greatest civilisations have all flourished in the temperate belt. Here man cannot live without effort; yet he is not, like the Eskimo, engaged in so fierce a struggle with Nature that he has neither energy nor opportunity for culture. Here man
A CHAIN BRIDGE IN CEYLON

It is the commercial instinct that has made man develop the means of communication. Upon commerce has depended the advancement of man from savagery to civilisation. This remarkable chain bridge, which spans the Ooma Oya river, is an important native highway.
How Commerce Spreads Culture

is sure of the reward of his labours; but he is not accustomed, like the African negro, to the expectation of the maximum of return for the minimum of labour. Climatic conditions are such as stimulate enterprise, develop energy and endurance, and ensure the rewards of industry. Man, in the temperate belt, has developed energy, skill, enterprise, foresight, and other accessories to power which have made him the dominant factor in the world he lives in. His immense reserves of mental and physical energy enable him to wrest from Nature materials for his business which are guarded by almost insuperable natural defences. He exploits the rubber, oil, and ivory of the tropical forest and the fever-haunted swamp successfully as he seizes the treasure of the Yukon gold mines, girt about though they be with mountain fastnesses and Arctic snows. He is by nature a captain of industry, and an organiser. For him toil the rubber gatherers in the Amazon Forest, the Kafirs in the Kimberley diamond mines, the dusky labourers in the sugar plantations of Demerara. To clothe his womenfolk he levies toll upon field and forest, mine and mountain, bird and beast. His simple meal is the collective result of human labour in all the four quarters of the globe; on his table lie the products of land and sea from the Frozen North to the Equator.

All are the results of successful commerce. For to secure even his breakfast coffee for himself alone would cost the daily maintenance of the town or suburb he lives in. Only the titanic machinery of trade and transportation, with its vast army of specialised workers, can secure for him cheaply, quickly, regularly, and certainly, even the most modest of his needs.

Commerce is, perhaps, the greatest civilising force the world has ever seen. Commerce has not only called forth man's finest qualities of intellect, enterprise, and endurance, but it has been ultimately responsible for much that makes for the world's progress. To it we must ascribe the spread of knowledge and the advance of civilisation. The spread of Greek culture was primarily due to Greek and Phoenician traders; the spread of Eastern culture, attributed often solely to the Crusaders, was justly due to the trade which was the natural outcome of the Crusades. To the rich merchant princes of Venice and Genoa we must ascribe the beginnings of that marvellous rediscovery of literature and of the arts known to us as the Renaissance. Their wealth—the reward of successful trading—gave them leisure for the collection and
Trade and Transportation

study of the priceless manuscripts and sculptures from the buried cities of Greece, Asia Minor, and Egypt—treasures which their own shipmasters had brought home.

To commerce we owe the vast progress which has been made in the development of means of communication. To carry on his trade successfully man has thrown bridges over great rivers and across stupendous chasms; has driven tunnels through mountain ranges, and under rivers, lakes, and seas; has harnessed great waterfalls, and has girt the world about with a network of steel railways and electric cables. He has cut roads through dense forests; he has filled in swamps and built great cities in their places; he has caused the desert to blossom like the rose; he has even yoked the lightning to the wheels of progress, so that it may propel his carriages and ships, drive his machinery, or enable him to bridge by wireless telegraphy a thousand miles in a fraction of time.

Commercial instinct, too, quite as much as the spirit of adventure, was the motive force which led man to discover the world by ever-widening travel and exploration. By travel man has explored his world, occupied it to his advantage, and shared his culture and experience among the nations. The necessity for finding a sea route to India was the cause of the Spanish and Portuguese discoveries of the fifteenth century. Vasco da Gama had no sooner discovered the new highway, when Portuguese traders began voyage after voyage round the Cape to the rich markets of Hindustan, and Portuguese ships pushed their way farther and farther east until, in 1575, they had established a trading settlement at Macao at the mouth of the Si-Kiang, a territory which they hold to this day. Christopher Columbus, too, sought the sea road to India, but he sought westwards, as many other navigators—Dutch, French, and English—did afterwards.

The history of trade is the story of human progress. In the interests of commerce terrible wars have been waged and bloody revolutions carried out. To successful commerce have contributed the privations of the explorer, the pioneer, and the frontiersman; the skill of the sailor, the scientist, and the engineer; and the wisdom and diplomacy of the statesman and the empire-builder. Upon commerce has depended the rise or fall of nations, and the advancement of man from savagery to civilisation.

Few natural products can be properly utilised by man without at least one stage of preparation; most of them pass through many changes before they reach a form in which man finds them most serviceable. They are "raw materials," which must be subjected to the process of manufacture.

In early times this preparation was effected by hand with the aid of primitive tools, and in the homes of the consumers or users of the finished article. Among primitive and half-civilised races this still persists. The average Sudanese village is a self-contained community which produces and prepares most things that it uses, and owes little to the outside world. Raw materials produced locally are worked up at home. Of course, there is specialisation of a kind. There is the professional worker in iron, as well as the professional medicine man. But weaving, the making of pots, and the manipulation of foodstuffs are part of the daily business of each family. Until the middle of the nineteenth century most of the textile and metal industries of the British Isles were domestic industries carried on in the home by means of tools or hand-operated machines. The master supplied each worker with a certain amount of raw material; the
In spite of all the progress made in steamship construction, about one-eighth of the world's shipping still remains under sail. Many sailing vessels are engaged in the nitrate trade with the West coast of South America. The most difficult part of the voyage is the strenuous battle against the "roaring forties" and the Cape Horn currents on the homeward trip.
The Industrial Revolution

worker and his family, each specialising in this or the other process of the manufacture, made up the material into the finished article. The invention of better and larger machines and the application of water-power led to the working of several families in a company. When the Industrial Revolution came about, and heavy machines operated by steam power were introduced, the old domestic system was superseded by the factory system, in which large numbers of workers were gathered into specially constructed buildings equipped with special machinery for production in huge quantities.

The general use of steam power led to the concentration of factories, and consequently of a thriving industrial population, on the coal-fields, where were the requisite stores of fuel for power, light, and heat, and of iron for machinery.

Vestiges of our old domestic system of manufacture still remain. Tweeds are still woven in the cottages of the Western Hebrides; woollen fabrics are still produced by the cottage folk of the Shetlands; and laces and linens are yet manufactured in the old way in Western Ireland.

Transportation is, generally speaking, the dominant factor in determining the location of a factory. Unless the necessary materials can be assembled at the factory, and unless the finished product can be sent to its market cheaply, easily, and quickly, no amount of other advantage is of much avail. Skilled workers are essential. They are not food-producers, but food-consumers, and must be fed from without—in other words, they must be placed within reach of a ready source of supply by an adequate system of transportation.
Hence it is that great ports like London, Liverpool, Bristol, Glasgow, and New York attract all kinds of manufactures. They may possess no local resources at all; yet their situation as control points on great lines of transportation confers ample facility, both for the assembly of fuel, machinery, and raw material, and for the dispatch of the finished products to the best markets inland and overseas.

To extend the application of the principle still farther, we may safely assume that the position of Great Britain as the greatest commercial country in the world is due not only to her home supplies of fuel and ores, but to her vast mercantile fleet, which dominates the trade of the world. Britain can assemble all kinds of material from all parts of the globe just as readily as she can distribute all kinds of manufactured products to the principal markets of the world.

It depends on the nature of the raw material whether it pays better to bring fuel and machinery to it, or to transport it to areas where fuel and machinery exist. Bulky raw material like sugar cane would cost much to transport to distant crushing mills. The machinery is erected on the plantation, and the extracted sugar is shipped to far distant ports to be refined. Similarly grain is threshed on the wheat-field, but is sent thousands of miles to be milled. On the other hand, hides from Argentina are sent to Massachusetts, to France, and to England to be tanned and worked up into manufactured articles, because in these areas already exist highly-skilled labour and good machinery, as well as materials for tanning. Vast quantities of raw cotton from the Southern States find their way to Lancashire for manufacture; millions of bales of wool from Australia, New Zealand, and South
Secret of Successful Commerce

Africa are sent to the woollen mills of Yorkshire; all because the complete association of the necessary power, machinery, skilled labour, transport, and markets is in being in those places, and therefore production is most profitable. Cotton mills are now being erected on the cotton-fields, it is true; also there are flourishing woollen industries in smelters of Swansea; the nickel, copper, and iron of the Lake Superior mining region go by the Lake waterways to Cleveland and Erie and on to Pittsburg, all of which are near huge supplies of fuel.

Transportation is thus the real secret of successful commerce. If adequate transportation does not exist to meet new

RICKSHAW BOY, NATAL

In Ceylon, Japan, and other eastern countries, as well as in South Africa, a favourite street vehicle is the rickshaw, drawn by a native runner

Australia; but the vast bulk of these manufactures must persist in those regions which by long adaptation and custom have become best suited for the work.

Metal industries—especially iron and steel manufactures, which employ very heavy materials—are usually concentrated on coal-fields which are equipped with good systems of transportation, and where, consequently, the materials can be most readily, cheaply, and expeditiously assembled. Copper comes from the world's great copper mines to the conditions of supply and demand, it will soon be created, often in face of considerable difficulties. Transportation is, in effect, a safe measure of a nation's efficiency.

The needs of the world's business have rendered transportation one of the most important factors of modern civilisation. The world's great markets and areas of production are linked together in a maze of railway lines and steamer tracks. Nations separated by leagues of ocean are thus united; and the civilised world is practically one great business
community, every unit of which depend in some degree on all the rest.

Man has always, in his struggle with natural forces, worked along the lines of least resistance. Thus it is that inland routes have usually followed natural highways, along river valleys or coastal plains, through natural gaps in mountain ranges or over low passes. The early trade-routes avoided natural obstacles—the road wound along round the foot of a hill, crossed rivers at fording places, avoided the marshland, and made a way through the less dense of the forest growths. In later days, when meehanical experience and skill gave him the power, man frequently and deliberately attacked and overcame obstacles in order to secure the advantage of time in transport when once his highway was made. Geographical disadvantages were overcome to secure commercial advantages. While early railways slavishly followed the lines of existing roads, modern railways show in startling fashion the amazing development of man's power in attacking and overcoming successfully all kinds of natural obstacles.

The first "beasts of burden" were human carriers. Porterage is the primitive stage of transport. It still is the only means of transport through tropical forests and swamps, and in mountainous regions where any other type of transport is impossible. Hunters "on safari" from Mombasa or any station on the Uganda railway, must employ a long train of native bearers to carry all materials for food, shelter, and defence during their wanderings in search of big game. Produce from the depths of the tropical forests is brought to the railway on the heads of native carriers. Before the building of the Nigerian railway, goods from the Guinea coast reached Lake Tehad—a distance of 600 miles—by Haussa carriers, at a porterage rate of £70 a ton.

Tea-coolies still struggle up the steep valleys of the Chinese rivers to the high plateau of Tibet for less than a shilling a day. Each man carries his load of tea-bricks, piled high on a little platform or rest till they reach high above his head. In the high Alps the human carrier is of great importance. Every man, woman, and child at work in the fields, in the forests, or on the Alpine pastures, carries the load in a specially-constructed basket or wooden carrier. When the cattle are taken to the high pastures for the summer, milk is brought down to the hotels in the valley by porterage, the human carrier bearing a huge wooden vessel strapped to his shoulders.

In Ceylon, Japan, and other eastern countries a favourite street vehicle is the "rickshaw" drawn by a coolie; while in China a common means of transport both for goods and passengers is the wheelbarrow, with its wheel in the middle of its load and a huge sail of matting hoisted to get the help of a favourable breeze. The Chinaman at the "helm" is motive power as well.

Pack animals provide a still more efficient transportation. Dogs, asses, horses, mules, oxen, Pack Animals camels, llamas, reindeer and elephants are all efficient workers and bearers of burdens in their own habitat. Each region naturally employs the animal which is best fitted for local geographical conditions. Over Arctic snows the Eskimo dogs or the swift reindeer provide the best means of transport. Huge weights are whisked along over a hard snow surface on a sledge drawn by a team of yelping "huskies," each harnessed by its own trace, and each ready to fight with all the rest of the team after a long stretch which would have run ordinary dogs to a standstill.

The beast of burden in the monsoon lands of Asia is the elephant, whose enormous strength and almost human intelligence make it the best helper man
Trade and Transportation

has among his animal workers. It can not only pull enormous loads and carry tremendous burdens, but it can be trained to sort out and arrange heavy and bulky materials. The favourite draught and pack animal among the Hindu farmers is the water-buffalo, whose formidable horns strangely belie his mild gaze and incomparable patience. The favourite draught and pack animal among the Hindu farmers is the water-buffalo, whose formidable horns strangely belie his mild gaze and incomparable patience. The favourite draught and pack animal among the Hindu farmers is the water-buffalo, whose formidable horns strangely belie his mild gaze and incomparable patience. The favourite draught and pack animal among the Hindu farmers is the water-buffalo, whose formidable horns strangely belie his mild gaze and incomparable patience.

The horse is universally used in regions where there is no special difficulty—either in the "going" or in securing supplies of food and water. In Egypt and Syria the ass is a common pack animal; it does everything, from carrying the lordly palace official to ploughing. It even acts as pantehnic when the Syrian makes up his mind to "move."

The camel is, perhaps, the most efficient of all animal carriers, quite apart from its special adaptation as a beast of burden in desert countries where no other beast could live long."

Over the grassy plains of the Argentine and of South Africa—the pampas and the veld—the usual means of transport far from the railways is the huge wagon drawn by its long team of trek-oxen—in South Africa always well "salted" as a precaution against tse-tse. Much of the early history of the prairie states and the mountain states of North America was made in the old "prairie schooners," or high-wheeled, canvas-covered wagons.

In mountainous countries the more sure-footed of animal carriers are requisitioned. In the mountains of Spain, Italy, and Switzerland the mule is the beast of burden. The only animal which can successfully negotiate the high passes over the Himalaya is the shaggy-coated yak. Ores from the mines in the mountain fastnesses of the Andes are brought to the rail-head by long "trains" of llamas.

Pack animals are a very efficient means of transportation. Each region naturally employs the animal which is best fitted for local geographical conditions.
Invention of the Wheel

He carries a load of at least 1,000 lbs. Over the Sahara great caravans, sometimes of 1,200 camels, move from oasis to oasis, taking about two years for the round trip, and transporting goods worth anything from £50,000 to £200,000. In the desert interior of Australia camels are of immense importane as means of transport. They were first employed successfully during the construction of the great Overland Telegraph Line (from Adelaide to Palmerston, on Port Darwin) in 1872. In South Australia camels are often harnessed in teams to heavily-laden wagons. A team of eight camels will easily draw a load of four tons at the average rate of fifteen miles a day.

The invention of the wheel as an accessory to transport rendered the construction of roads necessary. It is interesting to note that the Red Indians of North America, not many years ago, furnished an example of vehicular transport as it was before the invention of the wheel. They used the travois—two poles, each with one end fastened to a pony's back whilst the other dragged along the ground. About half-way along were cross-boards to carry the load. The device was exceedingly useful for conveying heavy loads over trackless prairie.

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Roads still carry much of the world’s traffic in spite of the growth of railways. The great strides made in motor transport suggest that the roads may win back a great deal of the business which the railways had won from them.
THE BOLAN RAILWAY

The enterprise of British engineers made a railway possible across the great barrier of the inhospitable mountains guarding India on the north-west. The first line constructed was swept away by the floods, but the existing line, which skirts the Bolan Pass, and passes over and through the mountain masses, has proved secure.
The Making of Roads

The first roads were mere trackways such as one still finds between one village and another in uncivilised countries. The development of vehicular traffic soon widened and straightened the trackways into roads. A track made in the first instance by wild animals, or perhaps by strayed cattle, is followed by man because it offers least resistance to his passage. It becomes a regular footway, and later a road; or perhaps even decides the direction of a great railway or the site of a flourishing town. Mere accident often plays a far greater part than geography in the settling of human affairs.

The Romans were magnificent road-builders. Through the territories they conquered they drove great, solidly-constructed roads, along which their fighting legions might swiftly be moved from one great armed camp to another, or from the camps to concentration points to repel an enemy. The trader followed the legionary. The Roman roads resounded not only to the tramp of armed men but to the noise of bustling crowds of merchants, the creaking of carts, and the clatter of many hoofs. The military ways became highways of commerce, and arteries along which flowed knowledge and culture—the very life-blood of civilising Rome.

Among modern road-makers the Swiss are, perhaps, pre-eminent. In the most difficult country in the whole of Europe they have constructed fine, durable roads, which zigzag magically over steep passes, or run with mathematical straightness down broad valleys. At one point the coach road over the St. Gotthard presents a most amazing spectacle of "hair-pin bends" and much multiplied zigzags. Where the Swiss road-builder has been hampered by masses of projecting rock or by the narrowness of a valley, he has set to work to cut tunnels for his road through the solid mountain-side.

Until the middle of the nineteenth century the English roads were the arteries of commerce and the highways of communication. The introduction, in 1815, of Macadam's system of road making and road mending, led to vast improvements in the turnpikes, and permitted the coaches—highwaymen and weather permitting—to run with clock-
 Trade and Transportation

like regularity. Great posting stables provided relays of fresh horses at every stage of twelve or sixteen miles, and the coaches ran to time like express trains. Country folk even set their watches by them. The roads were kept

in condition by using the bulk of the toll-money collected at the turnpike gates for the necessary repairs.

North America affords an extraordinary example of the swift transition from the primitive Indian trail to the well-constructed highway. Between 1750 and 1800 three great roads were built, each of which followed an Indian trail from the eastern settlements and towns to new settlements beyond the Alleghanies. The first of these roads—the Genesee—followed the Iroquois trail from the Hudson River to Niagara.

In “old countries” the railways have usually followed the established routes of the great main roads. They link city to city, town to town, village to village. Most of the cities, towns, and villages were there first, and had grown up at important points on the old roads—at the confluence of rivers, at fords, at the gap through a ridge of hills or a mountain range.

But in “young countries” like Siberia and Canada the railways have come first; the railway has determined the lines of settlement and the sites of towns; the position of the towns has not determined the route to be taken by the railways. The part played by the railways in the colonisation and economic development of western Canada and the heart of Siberia is incredibly great.

The development of the railway from the days of Trevethick, who in 1803 ran a road-locomotive, and of Stephenson, who was the engineer of the Stockton-Darlington railway, opened in 1825, to the modern triumphs of railway transportation is one of the most marvellous tributes to human enterprise and ingenuity. We can scarcely believe that in 1825 the Quarterly Review, in a withering criticism of the promises of
THE HIGHEST RAILWAY IN THE WORLD

The Oroya Railway, which runs from Callao, in Peru, to the top of the plateau at Oroya and Huancayo, reaches an altitude of 15,865 feet—higher than Mont Blanc. In the foreground is a llama train. These animals can carry heavy packs over mountains inaccessible to any other means of transportation.
the promoters of a new railway from London to Woolwich, said: "The gross exaggeration of the powers of the locomotive steam-engine may delude for a time, but must end in the mortification of those concerned. We would as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's rockets, as trust themselves to the mercy of such a machine, going at such a rate. We would back Old Father Thames against the Woolwich Railway for any sum." And the rate was—twenty miles an hour! Yet to-day the New York business man is ill content with the ninety-mile-an-hour rush of the Twentieth Century Limited!

There are probably few human enterprises which have called forth so much of man's courage, ingenuity, resource, and endurance as railway-building. Mountain ranges have been pierced by tunnels or surmounted by long zigzags and spirals; steep slopes, impossible of assault by grading, have been conquered by "eog railways" such as one finds in Switzerland for the use of tourists who seek the rewards but shun the labours of mountain climbing.

Four of the continents have transcontinental railways; Europe and North America by many different routes, Asia by the Trans-Siberian Railway, which brings Pekin within a fortnight of London, and South America by the joint systems of the Argentine Republic and Chili linking Buenos Aires with Valparaiso.

Australia as yet has only its transcontinental telegraph, but when Perth, in Western Australia, is linked with Adelaide in South Australia, as it soon will be by way of the Nullarbor Plain, there will be rail communication from Perth to Melbourne, Sydney, and Brisbane.

The Cape-Cairo Railway, one of the cherished dreams of Cecil Rhodes, is still in the making. The complex political conditions, and the still more serious difficulties which result from the climate and surface relief of Central Africa, have so far prevented the construction of the equatorial section. At present the northern section has been driven far south of Khartum to Sennar and Kosti, and west to El Obeid; the Cape section provides railway communication from Cape Town via the fine suspension bridge over the Victoria Falls of the Zambesi to Elisabethville and Katanga in the Congo basin. From the latter mining region there will shortly be rail communication to Benguela (Lobito Bay) on the coast of Portuguese West Africa.

Railways had their origin in the British Isles, where all the pioneer work in locomotive and track construction was also done. But we have to turn to the United States if we would see the most wonderful development of railways in the world.

America's first railway, the Baltimore and Ohio, was begun by Carroll in 1828. This was followed, in 1831, by the Mohawk-Hudson line, which grew into the modern New York Central. In 1830 the United States had only 23 miles of railway; Canada had none. By 1850 the mileage in the States had risen to 9,020; Canada had only 66. By 1880 the mileage had increased tenfold in the States (98,296 miles), and even more than tenfold in Canada (7,194 miles). In 1914 there were at least 235,000 miles of railway in the United States, considerably more than a third of the world's total. Russia came next with 48,000 miles; the British Isles had 23,250 miles; and Canada 23,000 miles. North America has nearly one-half of the world's railways; Europe about one-third.

To relate the marvellous feats of engineering achieved by modern railway builders a whole library of fascinating books would scarcely be adequate. In this brief general survey we must content ourselves with passing reference
Conquest of the Mountains

to very few, for we shall be able to view the chief of them in their proper setting in succeeding volumes.

The great Alpine railway tunnels provide a most extraordinary example of man's triumph over natural barriers. Four of these have long been in operation, bringing Switzerland in close touch with the markets of Europe.

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Another conquest of the mountains is the Trans-Andine Railway, which is carried over the high pass of El Cumbre at a height of 12,796 ft. by means of a summit tunnel. The great problem was not the boring of the tunnel, but the construction of the approaches to it, especially on the Chilian side. The porous soft rocks rapidly decomposed, so that approaches as well as tunnel had to be faced with twenty inches of concrete. Gigantic mud-slides, and the floods of the Mendoza River, when the snows melted, were the worst difficulties to be faced. The cost of these difficult 145 miles amounted to something like four millions sterling.

The advantages of this railway are obvious. The old difficult and uncomfortable route by sea from Buenos Aires to

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To these must now be added a fifth—the Lötschberg Tunnel, which links Kandersteg with Leukerbad in the Rhone Valley, and provides a direct route to Zermatt, the paradise of the Alpine climber.
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Valparaiso round Cape Horn—3,500 miles—is superseded by a safe and comfortable railway journey of about 890 miles. The saving in time is at least eleven days; the saving in hard cash for a first-class passenger is at least £20.

In this route we have yet another example of a great trunk line following the route of an ancient track-way. The Uspallata Route via El Cumbre was the way by which the Spaniards in the days of the Conquistadores found their way from Chile to the Plate River.

We may, in passing, refer to the wonderful developments of railways in Peru and Chile, where the mining and agricultural centres on the high plateaux are linked by rail with flourishing coast ports. The Oroya Railway, which runs from Callao to the top of the plateau at Oroya and Huancayo, reaches an altitude of 15,865 ft.—higher than Mont Blanc, and nearly four times the height of Ben Nevis—and, so far, is the highest railway in the world.

Most of the plateau centres, moreover, are being linked up by a line running along the plateau, just as Chilian ports are by lines along the coastal plain. The near future may well see the Pan-American project an established fact—North and South America may be connected by a continuous line through Mexico, Central America, and the high Andine plateaux.
Wonderful Bridges

Yet another remarkable railway is the Florida oversea line to Key West, the most important United States naval station in the Gulf of Mexico. The line crosses 156 miles of sea on huge concrete spans which step from one coral "key," or island, to another. By means of this undertaking New York has been brought twenty hours nearer to the tobacco, sugar, and fruit markets of Cuba.

Next to the giant railway tunnel, the feature of the permanent way which appeals most to our imagination is the great railway bridge.

Among the world's finest and costliest bridges we may note particularly the Forth Bridge — perhaps the most wonderful cantilever bridge in the world. It is a quaint comment on Western progress that the principle of the cantilever was utilised for bridge-building in China at least two thousand years ago!

There are dozens of little cantilever bridges in Tibet and Kashmir, where the car of progress still creaks slowly along. The Forth Bridge, with its 1,710 ft. span, took 4,000 men seven years to build up its 50,000 tons of steel. In spite of its great length trains dash across it in absolute safety at high speed.

Other wonderful bridges are the East River bridges at New York, the bridge over the St. Lawrence at Montreal, and that over the Hawkesbury River in New South Wales. The last has seven spans of 416 ft. each, which rest upon piers whose foundations had to be sunk by caissons through 40 ft. of water and 120 ft. of river mud.

London's tube railways are marvels of their kind, and provide the only solution to the traffic problem which had engaged
Trade and Transportation

Prairie States, where the absence of heavy gradients and the rapid growth of suburbs and new townships render possible the development of the light rail-road operated by electric power. By means of the various electric car services it is almost possible to travel from New York across country to Chicago.

Travel by water is as ancient as travel by land. Prehistoric man had his “dug-out,” from which he fished, and in which he made his way along rivers and lakes for short distances. In dense tropical forest and jungle the rivers are still the only highways for primitive and civilised people alike.

The exploration of Africa was first carried out along the great waterways. When once the problems of the Nile, the Niger, and the Congo had been solved, the exploration and opening up of Africa proceeded apace. Similarly the processes of exploration, conquest, and colonisation of the Americas were very largely directed by the courses of the great rivers.

The cheapness of transportation by water renders navigable waterways of vast importance to a country. Along the great navigable rivers like the Rhine, the Danube and the St. Lawrence, passes a great volume of trade between the seaports and the densely populated regions of the interior.

It is a significant fact that the actual tonnage cleared at Duisberg-Rührung on the German Rhine is greater than that at Hamburg. Mannheim again has water traffic which is double the ocean traffic of Bremen.

Yet another instance of the vast bulk of traffic which falls to the lot of natural inland waterways is the case of the “Soo” Canal which at Sault Ste Marie links Lake Superior with Lake Huron. The traffic of the “Soo” is four times that of the Suez Canal, and exceeds the combined tonnage of London, Liverpool and New York.

The Mississippi was North America’s main artery of trade until the coming of the railways—and that in spite of its natural hindrances to free traffic. On its banks there grew up a succession of flourishing river ports, where great fleets of shallow-draught steamers called on the voyage to or from New Orleans. The safer and swifter transport offered by the railways soon attracted most of the Mississippi trade; in 1886 more than twice the number of steamers called at St. Louis than was the case in 1906.

It is rarely the case, however, that a good natural waterway suffers from railway competition. Waterways and railways are complementary to each other in the matter of inland transportation.

Europe and the Americas are best supplied with natural waterways. Many of Asia’s great rivers have their mouths within the Arctic Circle, and are ice-bound for nine months of the year. African rivers are seriously hampered by waterfalls and rapids, often quite near their mouths, as in the case of the Congo. Australian rivers are of relatively small importance as arteries of trade, either on account of their seasonal variation and volume, or of their comparative smallness.

Canals are of considerable importance in most civilised countries, for they link one great river system to another, as in the case of the Rhine-Rhone, Rhine-Danube, and Rhine-Marne Canals, or they supply cheap water carriage to places which naturally lack that advantage.

It is a matter for regret that English canals have been allowed to fall into a condition closely approaching decay. They have never recovered from the competition set up by the railways; few of them pay any dividends; many are unnavigable. Yet it seems clear that a well-organised canal system in a busy industrial country like ours should be at least as useful as it has proved to be in Belgium and France.
The most wonderful example of a trans-isthmian canal is the Panama Canal. To break down the barrier which Nature has placed between ocean and ocean is a magnificent achievement. The amount of rock excavated at Panama would fill a tunnel 14 feet in diameter, reaching from one side of the earth and through the centre to the other.
The report of the Royal Commission on Inland Navigation (1911) suggests that the returns from an efficiently organised canal system would justify the expense to which the country might be put in improving the waterways and placing them under State supervision.

Perhaps the most important, as well as the most expensive type of canal is the ship canal. Ship canals are large enough to allow of the passage of ocean steamers; the chief types are (1) those which give deep-water access to inland ports; (2) those which are links in great systems of inland navigation; and (3) trans-isthmian canals, which link sea to sea and ocean to ocean.

Of the first type the Manchester Ship Canal is an excellent example. It has turned Manchester into a virtual seaport; cargoes of cotton consigned to Manchester mills can be transported thither from the United States without breaking bulk at Liverpool, as was formerly the case.

In this class we must include those canals which have given a new lease of life to old ports whose prosperity was decaying on account of the vast increase in the tonnage of ocean carriers. Havre and Amsterdam illustrate the case very well.

Where canals have not been cut for this reason, the result of the increase in the size of ships is seen in the establishment of “out-ports” nearer the deep water. Avonmouth for Bristol, and Pauillac for Bordeaux afford examples of this.

In the second class are included such canals as the German project for the linking of the Rhine and the Weser, in order to provide a Rhine outlet completely within German territory.

The trans-isthmian canals are, perhaps, most picturesque of all in their appeal to man’s imagination. To break down the barrier which Nature has placed between ocean and ocean is a magnificent achievement, well worthy the exercise of human ingenuity.

The Suez Canal, the Panama Canal, the Corinth Canal, and the Kiel Canal are examples of this type. Of these the most gigantic enterprise is, of course, the Panama Canal, which cost considerably more than the Suez, the Kiel, and the Manchester Ship Canals put together. Its completion means the triumph of man, not only in a problem of engineering, but in a struggle with Nature herself.

The grimmest of all Nature’s defensive battalions at Panama was tropical disease. Until this was overcome by Colonel Gorgas and his devoted band of fellow-labourers, by carefully organised hospitals and systems of sanitation, the completion of the canal was as impossible as it had been in the days of De Lesseps. To-day, it is said, mortality at Panama is considerably less than in many European cities.

The nature of the task before the Panama engineers may be imagined when one reads that the amount of rock excavated would fill a tunnel 14 feet in diameter, reaching from one side of the earth and through the centre to the other.

The real value of the canal is still a matter of conjecture. That it will bring about far-reaching changes in the general directions of the streams of world-traffic there can, of course, be no doubt. That it will lead to extraordinary economic progress in the Americas is beyond all dispute.

It is a question, however, whether we should go so far as to hail it as “the greatest readjustment of all time” in the economic balance of power. Less optimistic authorities than the one quoted above assert that the changes brought about by the Panama Canal will probably be less fundamental than those which resulted from the opening of the Suez Canal in 1869.

The Suez Canal will, of course, suffer little from the competition of Panama, since the traffic from Europe to the Far
The Age of Discovery

East and Australasia will gain nothing by forsaking the route it now follows. It will continue to use the Suez Canal. From Liverpool to Shanghai via Suez is a matter of 10,580 miles; via Panama the sea route is longer by 3,044 miles. Sydney, again, is 319 miles nearer Liverpool via Suez, than via Panama.

Where Europe will benefit most will be in trade with the American Pacific slope, which is now brought thousands of miles nearer by the Panama Canal. Liverpool is 6,046 miles nearer San Francisco by the Panama route than Tesseracontes, with her 4,050 rowers and her crew of nearly 8,000. We read, too, of the daring enterprise of the Phoenicians, who traced a close network of trade routes upon the Great Sea, and even undertook voyages to Gades (Cadiz) and Britain for tin. Much of their navigation was little more than a cautious creeping along the coast.

When the Age of Discovery dawned, however, fearless navigators like Columbus, the Cabots, Gilbert and Da Gama, struck out boldly into the unknown ocean in vessels of surprisingly small tonnage.

by the old route round Cape Horn. Iquique, on the north Chilian coast, is 2,800 miles nearer Liverpool via Panama than via Cape Horn.

The United States will, of course, reap the greatest immediate benefit from the canal. The Atlantic States are now within 5,300 miles of California by water. Before Panama was opened the water-route was 13,200 miles. The teeming millions of China and the East are brought as near the great American centres of production as they are to those in Europe, and must inevitably benefit by the resulting competition.

The development of ocean transportation is perhaps even more fascinating to follow than that of overland transportation. In ancient histories we read of wonderful vessels like the Egyptian ships of the Nile, and those of the Phoenicians, the Greeks and the Pharaohs; the bishop’s ship which brought news of the Magi to the infant Jesus; the swift carrack which brought spices to the knights of the Teutonic Order; the caravel of Columbus; the ship of the Armada; the clippers which crossed the Pacific in a few weeks; the clipper which brought news of World War I to England before it was known in New York.

THE MANCHESTER SHIP CANAL AT EASTHAM

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In the Victoria, a ship of eighty-five tons, Magellan’s sailors circumnavigated the globe, and fleets of similar vessels undertook regular voyages round the Cape between Portugal and the rich coast lands of India.

With the advance of Spanish conquest in the Americas, and the need of great fleets to convey the rich loot of Mexican and Peruvian cities to the greedy treasuries of Spain, there came the development of huge galleons and galleasses such as our sailors defeated in the Armada.

French shipbuilders soon surpassed the Spaniards; and by the beginning of the nineteenth century the young nation in the New World had taken the lead in the construction of ocean carriers. American “clippers” were the fastest things afloat,
UNLOADING A MODERN CARGO BOAT

To cope with the increase in the bulk of cargoes, and with changes in their character, a vast machinery has been created at all the great ports to provide for its swift handling and adequate storage. Work does not cease when darkness falls, for clusters of Imperial Lights make the night into day, and the toil of unloading goes on without interruption.
Specialisation in Ship Construction

and with clippers from Glasgow and other British ports monopolised the trade with China and India.

The age of steam saw remarkable developments in the size and speed of ocean carriers. From the little Clermont which steamed down the Hudson River in 1812, and the Sirius and the Great Western which crossed the Atlantic under steam in nineteen days in 1838, steamships have developed into the giant floating palaces which cross the "herring pond" in less than a week. The Sirius was a 412-ton paddle steamer, built at Leith in 1837 at a cost of £27,000. The ill-fated Titanic had a registered tonnage of 46,328 tons, and cost £1,500,000. The little Sirius could have found comfortable storage in one of the Titanic's holds.

Paddle wheels have been superseded by twin-screws, steel has taken the place of wood, and the ordinary marine engine has been ousted by the steam turbine.

It has seemed that in its turn the steam-engine is to be superseded by the oil-engine, especially in its application to ships, but so far the geared turbine has held the lead in spite of all the efforts of the advocates of the motor-ship.

What concerns us most, however, is the extraordinary specialisation in ocean-carriers in relation to certain types of over-sea trade. Specialisation in steamer construction ensures the nearest approach to perfection in ocean transportation, and to cope with the increase in the bulk of cargoes, and with changes in their character, a vast machinery has been created at all the great ports to provide for its swift handling and adequate storage, as well as efficient inland transport.

Petroleum is carried in tank-steamers specially constructed to carry oil in bulk. Huge pipe-lines from the oil-wells convey the oil to seaports perhaps a hundred miles or more away, where it is fed into the tanker.

A FOUR-MASTED CLIPPER

Certain Mexican ports with poor harbour accommodation feed tankers by means of pipes laid under the sea from the shore. The newest tankers either use oil-fuel, or are driven by Diesel oil-engines. At the port of consignment, the tanker is emptied by pipes along which the oil is driven by force-pumps to storage reservoirs.

Another remarkable illustration of the special adaptation of the ocean-carrier to the traffic for which she is destined is seen in the case of the steamers which carry frozen meat. The carcasses are packed in cold-storage chambers, whose double walls are filled-in with charcoal and other non-conducting materials, and whose low temperature is
Trade and Transportation

maintained by special refrigerator systems. Those in common use are the ammonia compression system and the carbonic anhydrate compression. Vessels engaged in the Jamaica fruit trade have also cool chambers in which the cargo is kept in excellent condition.

The coal traffic has its own special type of carrier. In unloading great modern colliers the coal is trimmed, put on conveyers, run ashore, and loaded in trucks—all by machinery, under the supervision of a handful of men whose business is indicated by a bunch of cotton-waste and an oil-cane.

At the terminal ports of the Panama Canal there is coal-handling machinery capable of unloading 1,000 tons of coal per hour, and of loading twice as much. In addition pipe-lines and pumping plants are provided at both Cristobal and Balboa for oil; as well as a pipe-line across the isthmus.

Another remarkable type of carrier is the ore-steamer, such as one finds at the wharves of the mining region of Lake Superior. By means of special shore machinery she can be loaded through all hatchways at once. The loading record up to the present is 260 tons per minute. She can discharge nearly 50 tons an hour.

In spite of all the progress made in steamship construction, there is still a large volume of trade which is carried in sailing vessels. About one-eighth of the world's shipping still remains under sail. The transportation of perishable and heavy goods renders the sailing ship a successful competitor of the steamer. A barque bound for Valparaiso from New York first sails eastward with winds and currents out to the Azores, where she hopes to pick up the north-east trades. She takes advantage of these in a long straight run to the South American coast; and she then sails south under the influence of the south-east trades.

The most difficult part of the voyage is the strenuous battle against the "roaring forties," and the Cape Horn currents, in order to win the way to the Pacific. Steamers, however, would take the straight run to Panama, and down the Pacific coast to Valparaiso.

The ocean routes which carry the heaviest traffic are those over the North Atlantic between Western Europe and the United States. Over these steam
The Insurance of Ships

at least one-sixth of the world's ships. Next in importance are the routes from North America to Western and Southern Europe, and thence via Suez to India and the Far East. Third we may place the stream of traffic between Western and Southern Europe and the Plate River on the one hand, and the Cape of Good Hope on the other.

These vast fleets of ocean carriers have given rise to an equally vast insurance business known to the man-in-the-street as "Lloyd's." Lloyd's, however, is not an insurance corporation, but a recognised meeting-place for "underwriters," or insurers of ships.

The present organisation has grown out of the coffee-house in Tower Street, kept by one Edward Lloyd, and frequented by ship-captains and underwriters. Since 1774 Lloyd's underwriters have been established in the Royal Exchange. At Lloyd's and on the "Baltic" Exchange is posted all the latest information regarding shipping—news which is collected from the thousands of Lloyd's agents scattered over the world.

Lloyd's Register, controlled by the Society of Lloyd's Register, is a different organisation altogether. Its business is the accurate registration of ships and their classification and full description for purposes of reference.

The society not only keeps accurate lists of ships, but wields a great influence over ship construction and equipment. For to be classified at all, a ship must conform to certain requirements laid down in the Register. R. J. F.
SIX METHODS OF SHOWING MOUNTAIN RELIEF

1. The “woolly caterpillar” style of representing mountain ranges; false representation of the Carpathians as a narrow line of mountains. 2. Panoramic drawing of mountains. 3. Hachures, or lines drawn down the direction of slope. 4. “Form lines” or approximate contours: the closeness of lines indicate steepness of slope, the figures, or “spot-heights,” are feet above mean sea-level. 5. Contours, hill shading and layer system. 6. Oblique “hill shading”
11. Maps and Map Reading

Meridians and Parallels—Route Traverses—Topography—The British Ordnance Survey—Triangulation—Alphabet of Conventional Signs—Relief—The Use of Maps

Since the world we live in is very nearly spherical the true shape of its continents can be represented with accuracy only upon a globe, and it is only with the globe that we can get a perfect idea of the relative positions of one place and another. But globes are inconvenient things even when they are on a small scale, and it would be hopelessly impossible to make our ordinary representations of the earth’s surface in such a very inconvenient shape. We are, therefore, driven to use maps, which are representations on flat sheets of larger or smaller portions of the spherical surface of the earth. And since it is well known that a flat sheet cannot be applied to a spherical surface by any process of merely rolling without stretching or tearing, it is clear that a map of any considerable portion of the surface cannot be a true representation.

The subject of map projections is that which treats of the best way of constructing a map in order that the inevitable error of representation may do as little harm as possible to the purpose in hand. The representation of trade routes, of distribution of population, or of the geological connection between the various continents will naturally require various treatments, and so a map projection which is good for one purpose will be very bad for another.

This explains why it is that the network of meridians and parallels which form the skeleton of the map is not always of one pattern. Sometimes the meridians are straight and sometimes curved. Sometimes the parallels are concentric circles; sometimes not. One kind of map will show distances from the centre correct, and another will show areas correct, while a third will do neither one nor the other, but will show the shape of large areas without undue distortion. These are the various considerations which the map maker has in his head when he decides what kind of skeleton he shall give to a particular map. And here we must leave this part of the subject, which rapidly becomes too technical for a work like this.

We have spoken of the skeleton of the map being the structure of meridians and parallels, and a little consideration will show that it is evident that this is the most convenient kind of foundation for the map to have. For the navigator at sea or the explorer upon land can, without much difficulty, by observations of the sun and stars, determine his latitude, and, with somewhat more difficulty, his longitude; that is to say, he can determine how far north or south of the Equator he is, and with less accuracy the distance of his meridian east or west of the meridian of Greenwich. Thus, if we have a framework of the parallels of latitude and the meridians of longitude we have always a convenient means of laying down any individual position.

The first rough outlines of a new land will usually be based upon these astronomical observations, especially if the land is bounded by a sea coast. The early navigators gave us rough positions of conspicuous turning points, such as
Maps and Map Reading

Cape Verde, the Cape of Good Hope, and Cape Horn; and little by little the outline of the coast between these points was fitted in as the seas became more frequented. It is not necessary that every point on the coast should be fixed astronomically; for the usual reckoning of the course of the ship by compass and log, combined with cross bearings of the more conspicuous points of the land as seen from the ship, would rapidly give a sufficiently accurate and far more detailed figure of the coast line than could easily be obtained in any other way. And so long as these were tied down, so to speak, from time to time by observations of latitude and longitude, the map of the coast line could not get many miles in error.

Then consider what the first traveller will do when he attempts to penetrate inland. The greatest part of his energy must be devoted to pressing ahead, to the care of his followers, and to the management of his supplies. He will have little time for map-making on any greater scale than is really necessary to enable him to know where he is himself, and to show where he has been. He will carry on on land very much as if he were at sea. He will keep account of his track by compass, time, and rate of march, just as the sailor keeps the log of his voyage. When occasion serves he will make an observation of the latitude and perhaps of longitude; and he will also—which is very important—determine the error of his compass. Thus the hourly record of his march will be from time to time adjusted to points fixed astronomically, and errors cannot accumulate to any great extent.

This was the condition of affairs in Africa until very recently. The coast line had been fixed by the marine surveyors in order to facilitate navigation. The interior had been traversed in many directions by explorers, and their "route traverses" had been pieced together so that we had an approximate knowledge of a good deal of the interior arrangement of the country—enough, at any rate, to make a respectable map on a scale sufficiently small, such as an atlas might give. But so soon as it became a
Topographical Maps

question of making a map of Africa on anything like a large scale the poverty of the material straightway became apparent, and the difference between the results obtained by various travellers became exceedingly inconvenient.

There is, in fact, an enormous difference between the small-scale atlas map and the large-scale map, such as one of the maps of the Ordnance Survey of England, say the map of two miles to the inch, commonly called "the half-inch map." Until one has tried it is difficult to realise what an immense amount of additional detail can be shown directly the scale of the map is doubled, and how empty a sheet will look if we draw on the scale of one inch to the mile the amount of material which will comfortably fill the half-inch map. In order to have a true appreciation of the present state of the mapping of the world we must get away altogether from the small atlas which gives the appearance of completeness in all parts of the earth and consider what countries are really properly mapped on "topographical" scales.

The aim of the topographical map is to present such a picture of the country that a traveller may derive from it all the essential information in advance of his journey: the character of the communications, whether by rail or road or river; the elevation of the country and the steepness of the slopes; the size of the towns by which he will pass; and all the various information that will enable him to get about with facility from place to place, whether he is bent on pleasure or business, whether he comes in peace or in war.

Especially for the operations of war it is essential that the map shall show not merely a diagram of the roads, rivers and railways, but a real representation of the shape or relief of the country.

On the other hand, a topographical map will not show boundaries of property or of the smaller administrative divisions. It will be a great mistake if the traveller's map is burdened with them, for they are

MERCHANT OFFICERS TAKING THE SUN'S ALTITUDE BY MEANS OF SEXTANTS

The vessel's latitude is worked out from their observations of no interest to him, and his map maker will want all the space he can get for more important things.

In spite of the enormous amount of money which in the last hundred years has been spent upon surveying, there is relatively only a small portion of the world which has been topographically mapped. Europe is covered in the greater part, though Spain is still very imperfectly mapped. In Asia we have the very complete maps of the Indian
Maps and Map Reading

"THE INSTRUMENT NAMED THEODOLITUS"

The earliest known reference to the Theodolite, from the Pantometria of Leonard Digges

Survey; the very much less complete maps of the Russian Empire; Japan; and some of the more valuable possessions of the European Powers along the southeast coast. In Africa one has Egypt and Uganda and the Orange River State, part of Cape Colony, and some of the tropical possessions of Great Britain and of Germany.

In North America the United States are pretty well mapped and a small amount of Canada is done. In South America work has not made very much progress, and in the whole of Australia there is not a topographical map that is worthy of the name. That is to say, in these countries which have, as yet, no topographical survey it is impossible to buy a map which is a sufficient guide to the operations of peace or of war.

And this in spite of the fact that an enormous amount of survey work has gone on in those countries. Railways, irrigation schemes, grants to mining companies, sales of Government land for farms and sheep runs and rubber estates, have all of necessity been conducted upon some kind of a plan, but the surveys for these purposes have been limited strictly to procuring the minimum amount of information required for the immediate purpose in view. The railway engineers have not troubled much about the country lying on each side of their track. The surveys for Crown grants of farming land have not troubled to show the relief of the land or anything but a rough outline of its rivers. And all this work has been done on different systems, on different scales, and with very varying degrees of accuracy.

Each piece was sufficient, perhaps, for its own ends, but it was not good enough to be fitted on to its neighbours with any precision, and the consequence is that when a systematic map of the whole country is wanted, it has to be begun as if no money had ever been spent on surveying in the land before. It is hardly necessary to point out the true economy of making a complete map of the country at the earliest possible moment.

Several million pounds, at least, were wasted in England because the surveys for railways, for the enclosure of commons, and for the commutation of tithe were all made independently before the Ordnance Survey was complete.

The British Ordnance Survey was one of the first precise national surveys to be undertaken, and it was conducted with a degree of elaboration which has, in
The Principle of Extensive Surveys

some respects, never been equalled. But its general principles are necessarily those of any other large survey, and familiarity with the localities will probably make it more intelligible to our readers if we give a brief sketch of the way in which the British Islands were surveyed than if we were to go farther afield.

The principle of nearly all extensive surveys is that one measures very accurately a few lines to serve as bases and builds up upon them a framework of triangles whose angles are all observed with the theodolite, and whose sides are calculated from the observed angles and from one or other of the bases.

The reason for this process is clear when one considers the difficulty of measuring the length of a line upon the natural surface of the earth. The obstructions of hills, of woods, of private property of all kinds, are so great that it is very rare to find a place in which one can measure for five or six miles in a straight line—so rare indeed that only two places were found to be suitable for measuring a long base with the appliances then available
—Salisbury Plain, in England, and the shores of Lough Foyle, in Ireland. But the measurement of the angles of triangles is unhindered by any obstacle in the intervening country, provided that the points of the triangle are sufficiently raised to give a clear view from one to the other.

Thus, the first operation is to choose a series of stations mutually visible, and forming a series of well-shaped triangles. In the flat country of the south-east of England it was necessary to have recourse, in some instances, to buildings. A scaffold was erected over the cross of St. Paul's, and another over the spire of Norwich Cathedral. But, whenever possible, the stations were built on the tops of hills. Many of the summits in the Lake country and in Wales have cairns of stones which cover the station marks of the "primary triangulation" of the country.

The theodolite for measuring horizontal angles was set up carefully over the mark at one station, while at each of the surrounding stations a heliograph was arranged to reflect the rays of the sun upon the theodolite station, for over the long rays, which were both necessary and desirable, it was impossible to see anything like an opaque signal. And it

TRIANGULATION WITH THE THEODOLITE
Cairns of stones are used to cover the station marks of the "primary triangulation" of the country

PLANE-TABLING
Travellers visiting unmapped regions should not neglect to take with them a plane-table (see p. 220)
Maps and Map Reading

may well be understood that in the clouded skies of England the observers had often a weary wait for the necessary hours of sunshine, so that at last one day, in despair, an officer of the Royal Engineers invented the limelight in order to make the connection between Wales and Ireland. Nowadays, the work would be done at night with powerful a e t y l e n e lamps instead of the heliograph.

When all the triangles are observed and connected with the bases, there ensues an enormously long calculation which eventually gives the length of every side of every triangle and the latitude and longitude of every point; and by mathematical processes, into which we need not enter, it is possible to obtain a precise idea of the accuracy with which the whole work has been carried out, and to make certain that the size and shape of this framework is known so accurately that there cannot possibly be any appreciable error in the maps which will eventually depend upon it.

With a foundation thus well laid, it is then possible to begin the actual work of making the map proper at any number of points, and to be sure that they will in the end all fit perfectly together. The difference between this process and that of starting without a framework is very much the same as the difference between that of making a large and complicated building with precise plans and that of trusting to luck as one goes along that the floors will be level and the windows in line, if one starts without plans.

The process of filling in one of the large triangles has been a great deal improved since the Ordnance Survey was made. In any case the big triangle must be cut up into a number of smaller ones and the details filled in. But nowadays such work is generally done with the plane table, instead of with the surveyor’s chain, with which the detail of England was mapped. Of course, most countries which have to be mapped now are not nearly so full of complicated detail as England is; and the process is relatively much easier.

We have now to speak of the determination of heights above sea, which are essential for a proper representation of the ground. It is generally accepted nowadays that zero height shall be the mean level of the sea round the coast of the country; not the height of high tide, or of low tide, or of the mean between the two, but the true mean level of the sea—that is to say, the mean of the heights at every hour over a long series of years.

Nothing less than this will serve, for the height of the sea is affected by the state of the barometer as well as by a great number of small tides of long period, so that it requires a good many years to average them out.

A careful determination of mean sea level at widely separated parts of the coast has an importance which is not confined
to providing a zero to the maps of the country. It serves the equally important end of showing whether, after the lapse of years, the country as a whole is rising or falling or tilting—questions which may be extremely important to a country of which a great part is nearly at sea level.

As originally planned the Ordnance Survey was defective in this particular. Its heights were based on the records of the tide gauge in the docks of Liverpool, on made ground, which may, for all one knows, have risen or sunk with changes in the load on the surrounding ground. Only within the last few years have steps been taken to provide for a precise and continuous determination of sea level at three widely-separated points—Newlyn, Dunbar, and Felixstowe. The records from these places will, in course of time, remove the reproach that we do not know whether our country is rising from the sea or sinking beneath it.

The next step in the operation is to run "lines of level" inland from these tide gauges. In choosing these lines it is important to remember that a great part of the country is mined for coal or for salt, and to avoid such places by choosing the principal lines of level along the older and the harder rocks. With such a framework of solidly-established "bench marks" it is quite easy to run secondary lines all over the country, except to the tops of the higher hills.

The heights of these latter must naturally depend upon observations with the theodolite, which are somewhat inferior in accuracy to the other process, and especially liable to error when the point whose height is required is inaccessible and must be observed from a great distance over snowfields and glaciers. The geography books gener-
Maps and Map Reading

carried up their triangulation as far as possible into the mountains, and from their farthest stations they have sighted upon as many as possible of these peaks. From Station A, perhaps a couple of hundred peaks can be seen. The observation with the theodolite gives the bearing of each one of these peaks that can be seen from A, and the angle of elevation of its summit above the horizon of A. When similar observations are made from B to another couple of hundred peaks, it is exceedingly probable that the selection seen from B will include some of those seen from A, but it is only in rare instances that a particular peak can be identified with certainty by its characteristic shape.

How then to select the peaks common to two sets? Observations must be made from a third point to a still other selection of peaks: a third set of bearings and elevations obtained. Now the whole material is handed over to the computing office at Calcutta, and the bearings are plotted. Whenever three lines meet in a point, it is pretty certain that one and the same peak has been observed from all three stations.

If this is so, its distance from each station can be calculated, and we may then proceed to deduce a height for the mountain from each observed elevation. If the heights come out very different, then it is certain that the intersection of the three rays was a mere chance. If, on the other hand, the heights come out the same within a few feet, it is certain that a definite mountain peak has been located.

Now this kind of work was going on as usual in the Computing Office at Calcutta, when they found that one mountain came out 29,000 feet high, and there was great excitement. Thus it is perfectly correct to say that the highest mountain in the world was discovered in Calcutta, and the whole story is a very good illustration of the way in which the Survey of India has pushed its observations across the Himalayas into regions which have never been visited, and which are, perhaps, forever inaccessible. But the travellers who, from time to time, succeed in penetrating somewhat farther into these splendid solitudes, and who try to map their glacier systems, have a very great advantage in the fact that they are usually within range of one or more peaks the positions of which have been fixed from India, to serve as firm points on which they may base the detailed maps of their explorations.

The traveller more remote from the operations of a well-ordered survey has much greater difficulties. Astronomical determinations of position take some time to make; and one is not always favoured with clear weather. A theodolite is a somewhat heavy instrument to carry to the tops of hills, while work of triangulation with it is slow and tedious.

It is here that the plane table proves its supreme value. On it one may make a map of a chosen area by purely graphical methods without any calculation, and, if necessary, without any astronomical observation of position. Only, in the latter case, the map will lack one essential. It will contain no indication whatever as to which part of the world it belongs to. Still, the traveller can carry on from sheet to sheet in the hope of finishing up somewhere on a fixed point; and if he can in the course of his work include two or three fixed points in his plane-table sketch, he will have produced a map which is sufficiently good for most purposes—if he is a skilful surveyor. Therefore, it should be urged upon all who go travelling into the unmapped regions of the world that whatever instruments they leave at home they should at least manage to take with them a plane-table.
Conventional Signs

It is time now that we devoted some attention to the map as a work of art, but art of a conventional kind, for the essence of a good map is that it shall be strictly conventional. By a gradual process of experiment map-makers have arrived at a system of conventions in which every stroke of the graver tells something of the character of the object represented, in addition to its mere place in the world; and the art of map reading consists very much in the power of appreciating at a glance the significance of this alphabet of conventional signs.

The manner of representing a road should tell not only its alignment but its character, whether it is a first-class metalled road fit for the motor, an indifferent road which is just passable for wheeled traffic in fine weather, or a steep mule track along which wheeled traffic is impossible. The little sign which represents the place of a town may be made to tell the degree of its relative importance, either in population, or in administration, or in history.

The type in which the name of the town is engraved is equally pliable. One may decide to show the rank of a town by its town sign, and its population by the lettering, or vice versa. The good atlas is careful to have a scale of town signs and type which gives very definite indications of the degree of the town's importance. Such desirable refinements need a very conscientious cartographer. One sees how easy it is to bring out a new edition of an atlas with the old plates unrevised; and, unfortunately, one sees it far too often in English maps.

Railways again must be classified so that the symbol in which they are drawn shall distinguish, at any rate, between the double line and the single line, and the light railway of narrow gauge, even if one does not go so far as some of the continental railway maps in trying to distinguish between lines on which there are express services and local lines, or between single lines with earthworks and bridges for a single track, and those which have had the embankments and bridges prepared for the eventual laying of a double track, though only a single track has actually been laid. Electric railways and rack railways up mountains give further opportunity for skill in contriving conventional signs.

However great the skill of the compiler and the engraver, it is difficult to procure a clear result without the use of colour, and it is due to the immense advances recently made in the art of colour printing that we are able now to get maps which are immeasurably superior to those of a few years ago. When it is possible to show roads in red or in yellow, water in blue, forests in green, and the relief of the country in brown or red, then we have, for the first time, the possibility of making a really legible map.

The real crux in map-making is the representation of the relief of the ground. Here we have to solve the problem how to represent three dimensions on a plane—to show the ground as solid without
Maps and Map Reading

obsuring either names or details. The old familiar "woolly caterpillar" way of drawing mountains gave, of course, an altogether false impression, and it was probably responsible very largely for the abuse of the expression "a mountain range," for it inevitably suggested a row of mountains at drill. It was altogether inferior in effect to the much older way of drawing a mountain range in a kind of panorama; which was illogical, but undeniably effective (see p. 212).

Next in the order of evolution came the method of "hachures," which sought to represent the direction of a slope by drawing a line down it, and the intensity of the slope by the weight and the closeness of the lines. The old maps of the Ordnance Survey, and of many continental surveys, are beautiful examples of engraving in hachures; and they give, undeniably, a good effect of relief, but at the expense of most of the other details.

Besides this disadvantage, hachures are very slow and expensive to engrave, so that they have given way to "hill shading," which is done by a much cheaper process, and is, by itself, poor and unsatisfactory. Until the ground is thoroughly surveyed, hill shading is, perhaps, the most convenient way of representing the fact that there are hills there, although we cannot say much about their precise form.

When one wishes to provide the maximum of information with the minimum of obliteration of other details, then it is well to employ contours, which are level lines run along the ground at equal differences of elevation above sea. If the contours are uniformly spaced in height, then the variety of their spacing horizontally gives a very precise indication of the degree of slope of the ground. When they come close together on the map the ground is steep. When they come so close together that there is a danger of obliterating other detail, then the ground is likely to be so steep that there will be little other detail to show.

It takes a little training to read contours well, but it is surprising how much can be learned from them when they are used intelligently: we have known men who could find their way in a dense mist in the Lakes entirely by reading the contour map and comparing it with the shape of the small area of ground that they could see. But above all things it is necessary to preserve the uniform vertical interval of the contours.

While, however, contours give the most precise detailed information about a particular piece of country, it is not so easy to read them at a glance over a whole sheet at once, and something more is wanted if we are to have a correct appreciation of the general relief of the ground in its boldest aspect. To meet this want the "layer system" has been introduced, in which thin washes of colour, graduated in intensity, are laid on between the contours.

Crudely applied, as it was at first, the result is generally unpleasing; but when care is taken to graduate the succession of tints in such a way that they pass gradually from one to the other in the order of the spectral colours, then the result is admirable so long as the ground does not run too high. In high, steep ground the contours are apt to run close together, and an immense number of layer tints is required if one is to preserve the principle that the tint shall change at every contour and the contours are spaced at uniform vertical intervals. Moreover, unless the layer of colour has sufficient breadth in which to develop its effect the significance of the small gradations is lost; and the tints themselves are confused by the colour of the contour lines when, as is often done, they are printed in brown or red.

Further difficulties arise when one arrives at the snow line, especially when, as in the case of the Himalayas, the snow
Three Essentials

descends much lower on one side of the mountains than on the other. We have seen in the last few years a great number of beautiful experiments in layer colouring, notably in the newest maps of the Ordnance Survey and of the Survey of India. It would be rash to suppose that the best possible results have yet been secured; there is plenty of room still for experiment in the happy combination of contours, layers, and hill shading.

The real trouble about these modern maps is that they are very expensive to produce, demanding a very high grade of technical excellence in drawing and printing, such as seems to be rare at present outside the printing offices of the official survey departments. It is not a little curious that while British Government printing is very nearly the worst in the world, British Government map printing is easily the best, and there is no private map printing which comes near it in quality—doubtless because the latter has to pay for itself, if not to make a profit; while in the former profit is a secondary consideration.

While, however, it is scarcely possible to hope that the ordinary atlas of commerce will rise to the heights of the best official work, there is plenty of room for improvement without expense, and it would be well if there were a clearer public demand for three things: lighter colours, more legible names, and fewer of them.

It is the greatest mistake to suppose that a map shall be judged according to the number of names which it contains. Doubtless it is convenient that there should be such a thing as the atlas which is nothing but a wilderness of names, because there are times when one wants to find out the location of some small and obscure place and expects the atlas to give it. But this kind of atlas should be treated like an encyclopaedia, with a vast range of information in a very unreadable form, and should be kept for reference only.

Another kind of atlas altogether is wanted for real geography, that is to say, for real representation of the land as Nature made it. This atlas should have few names. It should show political boundaries unobtrusively, not by a violent difference of colour. No complication of roads and railways should be allowed to interfere with the representation of the mountain watersheds and the river basins; and the purely conventional divisions between countries and continents should not be allowed to ruin the representation, let us say, of the Mediterranean Sea by leaving its southern coasts almost blank and, as it were, without the pale.

While in all these respects we have seen great improvements in the last few years, there remains much to be
Maps and Map Reading

done before it is possible to travel with pleasure and comfort upon a map, or to learn from it all that might be learned of the countries it represents. Half the charm of actual travelling comes with the meeting with strange tongues and foreign habits. Yet how frequently is travelling on the map spoiled by the unwarranted fondness of the map-maker for translating it into English. The name that one should find upon the map is the real name of a place, by which its inhabitants know it; not the Anglicised name by which neither its inhabitants nor any continental people would recognise it.

It is, perhaps, inevitable that prominent places of long and confused history should have acquired conventional names in different tongues; but the conventional names should be put in a bracket. Dimishk esh Sham is a better name than Damascus. Istanbul has a reality about it that neither Constantinople nor Stamboul nor Konstantinopel can suggest. To travel on a map such as the International Map of the World was meant to be, is a liberal education in languages and a most excellent exercise in schools. We have learned something in the last few months of the strange and unpronounceable names of Eastern and South-eastern Europe, and it is sad to reflect that if our maps had been better we might have been able to pronounce the names of those places which have been affording us such insuperable difficulties. It will be interesting to examine briefly the cause of these difficulties.

It is not only that Russian, Bulgarian, and Servian have many sounds which come with difficulty from an English tongue, and which need a liberal alphabet of from thirty-six to forty letters to express them properly—an alphabet, moreover, which is just sufficiently like a mixture of classical Greek and Latin characters to be deceptive to those who know one or the other. It is not only that the Poles and the Croats and the Czechs have tried to write their languages in the Latin character eked out with a liberal use of special signs and accents. The difficulties which we are now experiencing are very largely due to the fact that English maps of these countries have generally been made by a blind copying of the German; and that the Cyrillic character, or the Slavonic improvements upon the Roman, have suffered in the process of transliteration through German into English.

Similar difficulties very frequently arise from the various ways in which an Englishman, a Frenchman, and a German will represent the sounds that he hears in an African tongue, and it is quite an elaborate business to compile for English use a French or a German map of part of Africa.

We must now turn to the use of maps, and shall find opportunity of remarking as we go on how maps might be improved. Consider first maps on a fairly large scale, such as are useful for walking or for bicycling. In walking, especially through wild country where one may be overtaken by night or by fog, it is very important to have a compass with one, and very desirable to have a means of checking its accuracy from the map.

Now, the edges of a map sheet are often said to be north and south, but this is only very approximately true in the frequent case of maps with rectangular shape. The meridians, of course, converge towards the Pole, and on any projection which will be used for a land map the lines representing the meridian will be convergent, and frequently, though not necessarily, straight lines. The parallels of latitude will generally be circular arcs, and the small part of any such parallel which comes on a single sheet will be only slightly curved.
Marching at Night

It ought to be a universal rule that the sheet is bounded by meridians and parallels. The fact that it will not be rect angular matters very little in reality, yet the greater part of the surveys of Europe have preferred the rectangular sheet, with the consequence that the meridians, or the north and south lines, do not, in general, run parallel to the sheet edges. This is a very frequent source of error.

In using a map it is, therefore, important to look at once for the division of the edges, which shows the places where the meridians and the parallels cut the edge, and to note if these lines are carried across the face of the map as they should be. If they are not, it is often convenient to put them on in a coloured ink, and then it is not difficult with a protractor to take off from the map the true bearing of any ray or the angle which it makes with the meridian through the point of sight. Thus one may find very readily the deviation of the particular compass in use, which may very possibly differ from the deviation of the compass shown on the margin of the sheet, either because that information is out of date or because the compass has a peculiar error of its own.

An error of a couple of degrees in the compass is not to be despised; it throws one off the desired track about one yard in every thirty, which soon mounts up into a considerable error. Marching across country in the dark on a bearing read from the map at the start is quite an amusing sport, for it takes just a little experience to use the compass and the map and protractor with perfect confidence and without having to wonder exactly what to do. The man who can guide his fellows on a night march with confidence is in a happy position.

A march along a selected route by road needs a few precautions of a different kind by way of preparation. The principal difficulty is to know at once whether a road turning to the right is the road that one intended to take, or another road not marked on the map because it is, perhaps, only the entrance to a farm. There is a simple way to guard against mistakes in such a matter. One has to prepare in advance a programme of the times at which one expects to be at each turning point; and this is very quickly done with the aid of a time scale.

Suppose, for example, that the party marches three-and-a-quarter miles an hour and that the map is on the scale of one inch to the mile. In ten minutes one should evidently cover one-sixth of three-and-a-quarter inches, or 0.54 of an inch. Mark off on a strip of paper a series of spaces of this length, and subdivide the left hand one into ten parts, being careful to figure the time scale as shown in the diagram on p. 226. With this scale one can mark off immediately the time which would be taken on each section of the road; and one can thus prepare a programme which will make a mistake in the turning almost impossible, while the confidence gained by arriving at each turn within a minute or so of the calculated time will be inestimable. It is quite easy with a little practice, even if one is bicycling or driving, to read the map in time instead of in miles, and thus almost unconsciously estimate the time at which one should arrive at each important turn of the road.

In using foreign maps, which are generally made on the so-called natural scales of 1 in 80,000, 1 in 100,000, and similar round-numbered fractions, it is especially useful to an Englishman to make for himself either a time scale or a scale of miles, and there is very little difficulty in doing so, though the rules written out in the books are so tedious that probably no one ever remembers
Maps and Map Reading

TRUE AND MAGNETIC MERIDIAN DRAWN ON A SIX-INCH ORDNANCE SURVEY SHEET

them. There is just one number to bear in mind, one mile equals 63,360 inches, so that the map on the scale of one inch to the mile is 1 in 63,360. Hence on a French map to the scale of 1 in 100,000 the mile will be represented by 0.63 of an inch, and the scale can be drawn accordingly, while any other problem in the scale can be dealt with in an equally simple way.

Much more difficult is it to learn to read the relief of a map with certainty, for the methods of showing relief vary so very much on different maps. When there are no contours, no precise result can be obtained. But when there are contours fairly close together it becomes quite possible to draw an approximate section of the ground in any direction, and not much more difficult to construct the section in thought without actually drawing it; so that except in complicated cases one may usually form a pretty good idea as to what will form the sky-line from a given point of view, and whether one can or can not see a distant point over an intervening range. These problems of mutual visibility of points are apt, however, to be rendered of doubtful practical advantage owing to the existence of trees, which in a country of small relief are more effective in stopping a view than the actual hills.

Turn now to a very brief consideration of the ordinary atlas map. Its small scale, perhaps one in ten or twenty million, makes it necessary to exercise a severe economy in the choice of the information to be shown, and it very often suffers from trying to show too much, and from trying to show it too exclusively from the point of view of the country which is the principal, but not the only, subject of the map. There still survive atlases in which all but the most conspicuous detail stops suddenly at the frontier; but this bad effect is happily becoming rarer.

Yet there are still very few maps which show in a conspicuous way the really im-

TRUE BEARING, WITH PROTRACTOR, ON A SIX-INCH ORDNANCE SURVEY MAP
Possible Improvements

Important lines of communication over, let us say, a mountain frontier. In how many maps, for example, can one pick up at once the passes of the Alps or the Carpathians? To show them effectively they must be exaggerated, and made almost as diagrammatic as those most instructive little sketches of the military dispositions which Mr. Belloe introduced with so much success into his articles upon the Great War.

Another great improvement which might be introduced into atlases would be the index plate to show the limits of all the different sheets of the atlas. This is particularly necessary when the maps are drawn, as they should be drawn, in full detail for the whole of the sheet, not only for the country nominally the subject of the map. A map of Italy, for example, must necessarily include the Dalmatian coast and a good part of its hinterland. A map of the low countries will cover also part of the Rhine valley and part of Eastern England. An index diagram of the world, or of a continent, in which the boundaries of the individual sheets are clearly shown with their numbers, will be of the greatest help. The owner of an atlas will find it well to make such a diagram for himself at the first opportunity. And here it may be remarked that no one should ever hesitate to draw upon a map.

A few words in conclusion on the projected International Map of the World of the uniform scale of 1 in 1,000,000. It had been talked about for twenty years at Geographical Congresses. So long as it was the subject of pious resolutions that bound no one, it made no progress at all. But in the year 1909 the Powers represented by Ambassadors at the Court of St. James were invited by the British Government to send representatives to an International Committee which drew up a scheme, ultimately accepted by all the Governments concerned.

Some dozen sheets in all were produced during the three years which followed; and experience showed that certain modifications of the scheme were required. In 1913 a more widely representative Committee was summoned to meet in Paris, but at the outbreak of war, in August, 1914, the official report of its resolutions had not yet appeared. It is very much to be feared that the International Map of Europe will not now appear in its anticipated shape. Times are bad at present for international undertakings, yet a general map of Europe and the nearer parts of Asia on a uniform scale is very much wanted, for at the time of writing there is not in existence anything approximating to what the International Map would have been.*

* Since this was written the General Staff has begun the publication of a map on these lines, compiled under their direction, at the Royal Geographical Society.

A. R. H.