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MAN IN EVOLUTION

MAN IN EVOLUTION

BY

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To

My Wife, Shyama Sahni,
Whose Unfailing Help And
Constant Encouragement
Made This Book Possible

FOREWORD

THIS is not a book of the conventional type. It departs essentially from brochures on popular science in its method of presentation. It began in the form of short stories about man's evolution, related to the younger members of my family from time to time. The attempt, therefore, was not merely to give a simple exposition of the main scientific facts, shorn as far as possible of their technicalities, but also to create interest by the free use of simile and example, which objective was especially kept in view.

These pages have undergone much emendation from their original to adapt them for young students of science, particularly those aspiring to their Bachelor's degrees in Geology, Anthropology or Zoology. It is also hoped that the layman will find sufficient interest to glean some idea of an unfamiliar theme. In order, therefore, to place this subject in its wider perspective, it was thought not only desirable but essential to consider related aspects of this problem (e.g. the principles and major landmarks of evolution, the antiquity of the earth and of life on the globe, and even certain fundamentals of geology) so as to form a suitable background for the main theme of man's evolution. No apology is therefore needed if these indirectly or even remotely related problems have been dealt with in some detail.

It may be further emphasized that the aim has been to deal mainly with the organic and physical evolution of the human race, not its mental and moral development, which can be safely left in the hands of the philosophers, whose numbers today are as great as ever; or even with the politicians, of whom, alas! there is no dearth, judging by the kaleidoscope of international events.

In spite of its importance, one can only hope to touch the mere fringe of this vast problem. The Palaeontologist (the scientist who deals with fossils and studies the life of past ages) attempts to unmask the panorama of forgotten eras, of time buried deep within the bosom of Eternity. He tries to rebuild prehistories from scanty relics and remnants, and he builds ancient geographies like a child his jig-saw puzzle; he tells us of the continents that have foundered into the sea or

risen from the ocean depths; of continents that have, perchance, drifted apart like friends unable to retain contacts of friendship. And he lays bare the great drama of man's evolution, with its varying actors, some rude and uncouth, some more refined, who, having played their glorious or inglorious parts, walked off the stage—for ever. And the Palaeontologist also tells us to be the wiser for past experience, to listen to the verdict of evolution; in short, to take heed lest the race of man perish by the will and wish of man—but of that anon.

In spite of the progress of science the early beginnings of man are still enshrouded in mystery and we often grope in the dark, looking for broken remnants of clues and undeciphered bones; and yet, like the composer who has recalled to mind the strains of some forgotten melody, we often catch glimpses of sparkling light which give us courage and inspiration.

Geology[1] and palaeontology[2] have given much to humanity—coal, oil, minerals, precious stones and industry. But little did we realise that these sciences also gave humanity some of its saints. J. B. S. Haldane asserts that, for example, St. Protasus and St. Gervaise were probably no more than ordinary mortals of late Palaeolithic age, whose sanctity is ascribed to the fact that after their bodies were decapitated and the flesh removed, their bones were besmeared according to Stone Age custom with red ochre, which simulated blood, so that when these bones were unearthed near Milan, they were acclaimed as those of saints. It is even reported that while being transported from their ancient to more dignified graves, their touch cured the sick and ailing on the way. In reality, however, these 'saints' were only fossilised representatives of the Cro-Magnon race of 30,000 years or more ago, whose sex is unknown and who might even have been the victims of a cannibalistic ritual. So that geology and palaeontology gave to Christianity saints, who acquired their sanctity by "sheer luck" and pious misinterpretation. And that is more than chemistry or physics or even mathematics has ever achieved, in spite of the belief that numbers can prove almost anything.

[1]Greek, *ge* = earth, *logos* = science, meaning the science of the earth.

[2]Greek, *palaios* = ancient, *onta* = living things, *logos* = science, meaning the science of past life, both plant and animal. The science of past animal life is sometimes distinguished as palaeozoology and that of ancient plants as palaeobotany.

The author is fully conscious of the frequent references to the antiquity of various geological and biological events in terms of millions of years, even though orthodox science might look askance at them. His sole excuse is that he has rarely, if ever, talked to a layman on this subject without being immediately posed a volley of questions demanding the age of this fossil or of that geological event in numbers of years. "How old is it ?" is invariably the first question asked. Surely then no harm can come if the layman's just curiosity is satisfied, even if one is out by a few million years in presenting this awe-inspiring galaxy of figures.

Some at least of these pages were written during long and laborious railway journeys, or during equally long interludes at railway stations which would have been, at the best of times, a good test of one's patience. But there is a brighter side to every picture, for these war-time 'amenities' gave the writer opportunities of working on this book. If these pages, in spite of any shortcomings, succeed in imparting some knowledge concerning the physical evolution of the race to which the reader has the misfortune to belong, our object will have been well served.

Acknowledgements

I wish to express my deep gratitude to Professor F. E. Zeuner of the Institute of Archaeology, London, with whom I had the opportunity of discussing the subject-matter of this book while he was in India and who gave me many valuable suggestions. I am also indebted in many ways to Dr. A. M. Heron, lately Director, Geological Survey of India, and Dr. S. L. Hora, Director, Zoological Survey of India, whose wide scientific interests have always been a source of inspiration. My grateful thanks are due to Dr. S. M. Katre, Principal of the Post-graduate and Research Institute, Poona, for generously sending me publications of the Institute. The excellent work which the Institute is doing cannot be too highly commended. I am much beholden to Mr. P. E. P. Deraniyagala, Director of Museums, Ceylon, for literature and for drawing my attention to recent discoveries regarding the prehistory of Ceylon to which he has contributed so much. I am similarly indebted to Mr. B. B. Lal of the Archaeological Survey of India for his prompt response to my enquiries.

I am also indebted to Mr. P. D. Malhotra for attending to various matters connected with proof reading. My special thanks are due to the Editorial Staff of Orient Longmans for the great pains and interest they have taken in the production of this book—personal interest which often went beyond the pale of what one normally expects.

To my wife Shyama Sahni, I dedicate this book in gratitude for help given in many different ways during particularly difficult and unsettled times. Last but not least, I have to thank my daughter, Kamini, who in spite of preoccupation with her own studies, drew the illustrations for this book and also designed its cover.

Lucknow, 24th December, 1951 M. R. SAHNI

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CHAPTER I

A BIRD'S-EYE VIEW

An Invocation

SEVERAL years ago in the stillness and haze of a winter's morn—we crossed a dangerous hill river in the hinterland of the Shan States of Burma, on a frail bamboo raft improvised on the spot for the purpose. For safety we relied upon a negligible capacity to swim in case of mishap. And we noticed that the bullock-drivers who accompained us, before driving their beasts of burden into the stream for the passage across, burnt incense on the branch of a wild maple and prayed for the safety of their cattle —and presumably of themselves.

We thought that the bullock-drivers felt much safer than we did, there being all the difference between a raft and a prayer, even though we had never prayed (except during childhood when we hoped that the mathematics teacher would have his turn of the ague, or that at the very least, his bicycle would be effectively punctured). We cannot tell whether the prayer would have made much of a difference to the mighty Namyau[1] if any of us, man or beast, had been put on trial. But the invocation, which is customary when embarking upon auspicious or hazardous missions, seemed to help and to give added strength. Today we find ourselves much in the position of those bullock-drivers, and in embarking upon the hazards of a work of this nature, we invoke to our aid the spirit of the noblest fossils, from the insignificant cockle-shells to the great dinosaurs and the multitude of our own ape-like ancestors, lying buried deep within the bosom of the earth, since aeons past.

After this invocation, a custom sunk deep in our core by ancient tradition, we may commence our story—a panoramic review of the episode of man's evolution—with a warning. For we promise to make an honest attempt to tell the truth, which, as you know, is often bitter. Therefore, my dear reader, if you think a lot of yourself and are unable to face disillusionment, probe no further into these pages.

[1]Shan, *nam* = water, *yau* = big, therefore, literally, Big Water or Big River.

Our Principal Ancestors

Man being his own historian, his own biographer, his own judge and jury, has placed himself upon a high pedestal, and even upon the altar of divinity. But the facts of science tell us, as you will see in the pages to follow, that man, being a mammal, had reptiles as his ancestors (this is the Class[1] to which snakes, lizards and crocodiles belong). His earlier relatives were amphibians, animals that can live both in water and on dry land, of which the frog is the most familiar example. And his still more remote ancestors were, in unbroken succession: fishes, lancelet-like forms (classed with the chordates), relations of sea-urchins and sea-anemones, coelenterates and, finally, minute single-celled organisms, the protozoa—an ancestry as proud as any one could wish or hope for (Fig. 1). Among these, the modern lancelets are regarded as relations of the forerunners of the vertebrates or even as the most primitive vertebrates themselves. They belong to one of the most interesting groups of the Animal Kingdom. Their twin brothers are the tunicates, also known as the 'sea-potatoes' or 'sea-squirts', which are degenerate members of the same group of 'chordates', the larval stages of which have been found to resemble the hypothetical ancestors of man on the early chordate level. About all these we shall have more to say later.

These major groups have survived through great spans of time, covering millions of years. Compared to these, the total period of man's existence on the earth—about a million years —is but a fleeting moment. (See Fig. 2 which illustrates the time-ranges of the major vertebrate groups).

The Beginning of Life: a Probable Cause

Now to go to a step backward, one may reasonably enquire, What are the essential conditions of life? What is it that separates

[1]Animal and plant life is classified into groups of varying importance upon the basis of the relative degree of their relationship. These groups are, in descending order : Kingdom, Phylum, Class, Order, Family, Genus and Species. The two Kingdoms are divided into several Phyla, each Phylum into Classes, each Class into Orders, each Order into Families, and so on. Thus, man belongs to the Kingdom *Animalia* (Animal Kingdom), Phylum *Chordata*, Class *Mammalia*, Order *Primates*, Family *Hominidae*, Genus *Homo* and Species *Homo sapiens*. The chimpanzee, one of the anthropoid or man-like apes, is grouped into the same Phylum, Class and Order as man, but thereafter diverges and is classed in the Family *Pongidae*, Genus *Pan*, and Species *Pan chimpanse*. This classification expresses the degree of relationship between the two, which is the main purpose of all classifications.

		PERIOD AND DATE OF ORIGIN IN YEARS B. C.	
MODERN MAN *Homo sapiens*		U. Pleistocene	100,000
	NEANDERTHAL GROUP NEANDERTHAL MAN	L. Pleistocene	450,000
	PITHECANTHROPUS GROUP JAVA APE MAN	L. Pleistocene	550,000
SUB-MEN	Nearest approach to so-called 'missing-link,' e.g., *Australopithecus* *Plesianthropus*	U. Pliocene	3 million
ANTHROPOID APES	Large Apes	L. Miocene	25 "
	Small Apes	L. Oligocene	35 "
TARSIERS	Early Primates	L. Eocene	55 "
TREE-SHREWS	Now generally included in the Primates	Palaeocene	65 "
INSECTIVORES	Primitive placental mammals e.g., hedgehogs or shrews	U. Cretaceous	80 "
MAMMALS		U. Trias	160 "
REPTILES		U. Carboniferous	210 "
AMPHIBIA		U. Devonian	260 "
FISHES		U. Ordovician	380 "
LANCELET-LIKE FORMS	e.g., the living *Amphioxus*. The only known fossil form is *Jamoytius*.	These are all unknown in the fossil state, except *Jamoytius* (U. Silurian) of about 325 million years ago. They would have originated in *successively* earlier times, commencing about 400 million years ago. The earliest forms (Protozoa) appeared at least 500 million years back.	
FORERUNNERS OF SEA-URCHINS			
COELENTERATA			
PROTOZOA	Microscopic, unicellular organisms:		

Fig. 1. Man's 'Family-tree' for the last 500,000,000 years, being a bird's-eye view of the major steps in evolution. Ancestral stages prior to the Fishes are based entirely upon embryological evidence.

the living from the non-living ? Where exactly can we draw the dividing line between the two? In short, ultimately, we want to discover the cause of life. Answers to these questions, except the last, are not far to seek, for it is clear that all living beings take in and assimilate other matter as food, or, as we say in the case of the higher animals, *they eat.* As a result of this *they grow,* and, at maturity *they reproduce,* that is, give birth to their own kind. A stone or a piece of dead bark will not eat, will not grow, nor will it reproduce. A railway engine, even if she takes in coal and water, does not assimilate them, nor does she grow, and even if she runs faster than the fastest sprinter and whistles louder than the most practised whistler, she has certainly never been known to give birth to a baby engine ! Although certain mineral crystals are known, in a sense, to assimilate matter of their own kind and grow (and even to 'twin'!),[1] yet they cannot reproduce. Thus, to repeat, it is in the nature of living beings alone to eat, to grow and to reproduce their own kind.

But the question of all questions is, How did living beings acquire these qualities; in short, how did they acquire life ? Frankly, to answer this question needs not only the skill of the scientist, his observation and experiment, but also the inspiration of the philosopher and the poet, and it has not been adequately answered yet.

However, to give such suggestions as the scientist has been able to put forward, the immediate physical cause was perhaps a relatively simple one, and such as the scientist might one day be able to reproduce in a test-tube. This of course describes merely the possibly physical basis of life. That life is a peculiar phenomenon from the philosophical and spiritual point of view is amply demonstrated by its having a purpose. Science cannot explain this aspect of life so that there is ample scope left for the views of the philosophers.

It is suggested, then, that from the physical point of view life began with some unusual chemical combination in the water (not on land) at a time when the general conditions of the globe were presumably different, though it is not known exactly how or in what direction, from those obtaining today; nor is there

[1]This is a scientific term used to define certain mineral crystals of identical shape which sometimes grow in pairs though in physical continuity with each other. The phenomenon is known as 'twinning'.

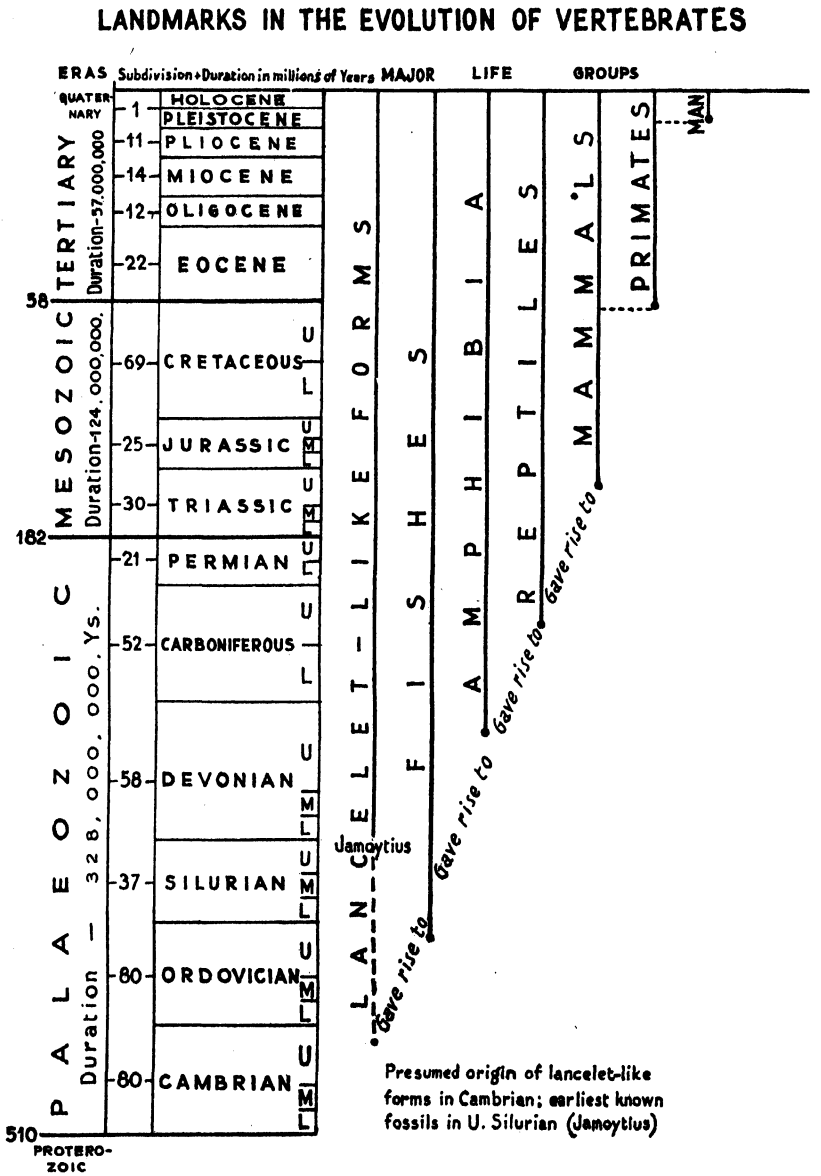


Fig 2. Time-ranges of the major life-groups concerned with the pedigree of man.

any proof thereof. It is, at any rate, probable that at some early stage in the earth's history one of the stable chemical compounds was able to assimilate other matter as food, that is, to eat, and to build up more of itself. Thus one of the essentials of life was acquired. To grow was a natural corollary. Scientists have even been able to produce in the laboratory chemical compounds which have much of the semblance of living organisms, but which are unable to reproduce themselves. How, at the dawn of time, similar specks of matter began to assimilate food and reproduce their own kind, and put 'life' into themselves is still a mystery which will probably remain unsolved for a long time yet. In short, this is a confession of defeat. And man, the philosopher and scientist, who in his unrestrained pride sometimes regards himself as the mightiest of the mighty, knows as little of whence life came, as he does of the Kingdoms beyond, whither all must inevitably travel when that glorious and divine spark called Life is extinguished into eternity, like the pale candle-flame by a mere whiff of the evening breeze !

And, finally, if the reader were to enquire, Is new life coming into existence today? the answer is, Who can tell? It is, however, quite conceivable that life took shape more than just once, and if so, it seems possible that new forms of life are, under favourable conditions, even now being created.

Origin of the Earth and other Planets

The earth was the stage where the great drama of man's evolution was enacted and where man's destiny is being decided today. Now we may pertinently enquire, What was the shape and form of the earth and its physical condition, prior to the commencement of life upon it? To answer this we shall first consider two of the popular hypotheses concerning the origin of the earth and other planets.

The German philosopher Immanuel Kant suggested, in 1754-55, that in its original state matter was cold, and filled the universe like a cloud. Gradually as the result of gravity, parts of it collected round a centre and finally developed into the sun. Other planets and various heavenly bodies were similarly formed, and in travelling towards this centre they began to rotate. Kant argued that the contraction of the sun gave rise to its heat.

Later, in 1796, the celebrated astronomer Laplace came to the conclusion that the original nebula was a great mass of various hot gases, a part of which finally solidified into our planet by gradual cooling. Some, however, believe that it may have consisted of myriads of small metallic particles, among them iron and nickel, still in a very finely divided form. The nebulae

Fig. 3. The spiral Whirlpool Nebula in the constellation, Hunting Dogs (*Canes Venatici*), 10,000,000,000,000,000,000 miles distant from the earth. According to the Nebular Hypothesis the earth and other planets originated from nebulae by gradual cooling and solidification. A vast number of nebulae has been discovered by the use of powerful telescopes.

are really masses of stars very far removed from our own cluster of stars, the Milky Way. The latter, if seen from one of those nebulae would probably appear as they appear to us. Nebulae can be seen even today through the telescope, in certain constellations of stars as, for example, in that of the Great Bear (*Ursus Major*), and in the constellation of the Hunting Dogs or *Canes Venatici*, in which cases the nebulae have a spiral shape (Fig. 3). Such star nebulae, then, are made up of numerous stars. The sun is just one of these stars and the earth a planet revolving round the sun. How was the earth formed? Laplace

believed that the earth and the other planets were shed as rings by the main gaseous mass owing to centrifugal force and gradual shrinking, while the contracting mass of this parent formed the sun. After separating from it, the earth cooled still further, till the temperature was sufficiently low to permit moisture to condense, clouds to form, thunder and lightning to enliven the monotony of primaeval day. With it commenced the train of geological processes—disintegration of rocks, their deposition as clay, sandstone, gravel, conglomerate, limestone, etc., with which we are all familiar today.

Another interesting theory concerning the earth's origin is embodied in the Planetesimal Hypothesis. According to this view, which accepts the previous existence of the sun, the original earth was probably the result of an accident. It is believed that at some remote period a big star, possibly a comet, passed so dangerously close to the sun (which is, strictly speaking, just another star) that it resulted in the partial disintegration of the sun owing to the tidal pull exerted by the big star or comet. This gave rise to a number of small masses—the 'planetesimals' or small planets—composed of solid particles. These constituted the cores of the planets. They began to rotate at very high speeds round the sun and, after cooling, formed the earth and other planets.

Incidentally it may be mentioned that some people believe the moon itself was a part of the earth and was separated from it by a similar tidal pull in earlier times and that she originally occupied the basin of the Pacific Ocean. The void left by the departure of the moon (whose volume fits almost ideally into the Pacific basin) was filled by the ocean waters ! Some say that this happened as late as the end of the Cretaceous period[1]. There is, however, no geological evidence in support of this view, for events of such magnitude would be expected to produce vast cataclysms, leaving their trail behind, and to reflect themselves in the changed panorama of contemporary life. Although the end of the Cretaceous period about 60 million years ago does mark an epoch when many of the huge dinosaurs of the Mesozoic era met their doom, when many plant forms saw their decline, even though the flowering plants came into prominence

[1]This is one of the subdivisions of geological time. The significance of these divisions is explained more fully later.

when the mighty Himalayas began their effort to peep above the level of the sea, and when sheets of burning lava thousands of feet thick were poured out from the bowels of the earth, the entire region of the present Deccan plateau becoming one vast sea of lava; yet these phenomena were not of sufficient intensity to be accounted for by the birth of the moon from the womb of the earth.

If the moon formed a part of the earth at any stage, she must have departed from the earth much earlier than the Cretaceous period, possibly at a time when the earth was still in a semi-molten condition, long prior to the inception of life on the globe.

Whatever may be its origin, judging from the present condition of the earth, neither the geologist nor the astronomer can find evidence in support of the Nebular or Planetesimal hypotheses and these and other theories about the origin of the earth belong, to the realm of scientific speculation.

The most recent theory which explains the origin of the earth and other planets and also of the stars is that proposed by the mathematicians, F. Hoyle and A. Lyttleton, both of Cambridge University. It goes to their credit that at the time they put forward their new and revolutionary ideas (1937), Hoyle was only twenty-two and Lyttleton twenty-five.

In order to gain a clear understanding of their views, it is essential to explain certain basic principles. Firstly, it is known that the stars are composed mainly of the gas hydrogen and that their luminosity is the result of nuclear reaction which changes hydrogen into helium. Secondly, that while the stars are of fabulous dimensions, they contain but an infinitesimal portion of the total matter present in the universe. The remaining portion is diffused into space between the stars as interstellar matter. Indeed, this interstellar matter can be actually seen as dark patches of varying shapes and sizes scattered in the universal space, including our Milky Way. According to Hoyle and Lyttleton, these vast interstellar hydrogen clouds become denser and denser by the accumulation of more material which travels towards their centres by gravitational force. As a result, the temperature in these dense hydrogen masses becomes high enough to bring about nuclear reaction, changing hydrogen into helium. These masses begin life as ordinary stars and may remain as such for many, many million years if they do not take in further

material. In such stars, which may be called *stable*, the amount of heat radiated just balances that escaping from their surface. To this category belong our sun and many stars that are seen in space. However, all stars are not stable and many collect much larger quantities of interstellar hydrogen than is good for them, so to speak. The result is that they burn up much faster than the stable stars. This brings about nuclear reactions and produces temperatures which are far above (about three hundred times) that of the sun. At the same time, heavier elements such as iron and uranium are formed. It is evident that such nuclear reactions result in considerable dissipation of energy on account of which the star contracts and finally collapses with a sudden explosion. A very important point to bear in mind is that the contracted star revolves at a speed far greater than that of the sun. The full significance of this will be apparent presently. Such stars which go through the stages explained above and which finally burst give rise to *supernovae*. Nothing remains of them after the explosion but an insignificant white nucleus. It will interest the reader to know that such *supernovae* are believed to have occurred twice within the span of historic times. One of these was seen as a star in broad daylight for several days in 1572, and was discovered by Tycho Brahe. The other was noticed in China and Japan as early as A.D. 1054.

Let us see how the origin of the planets is connected with these *supernovae*.

Astronomers tell us that about half the number of stars that are visible belong to *binary systems*—meaning a pair of stars revolving around a common centre. Now if one of these stars follows the path of indiscretion and becomes a *supernova*, its major portion gets scattered into space as a result of the explosion, but a part of it remains within the influence of its more discreet partner as a disc of enormous size. According to Hoyle and Lyttleton, the planets and their satellites arise within such discs by concentration and gradual cooling of the heavier parts of matter including iron and uranium which remain within the disc and which, indeed, bring about the explosion of the star. The subsequent history of the planets needs no elaboration. Our present sun is considered to be the more discreet partner of one of these *binary systems* of stars, the planets, including the earth, being the result of the bursting of its companion star as already

explained. Since the planets revolve at much greater speeds than the sun, it is obvious that they could *never* have formed a part of it as some theories envisage. Indeed the explosion, as a result of which the planets were born, also explains the disparity between the speeds at which the sun and the planets revolve, the greater speed of the planets being due to the momentum which they received when their parent star (*supernova*) exploded. It has been estimated that the sun will last 50 billion years. Thereafter it will probably gain more heat and will annihilate all life on the earth. It will ultimately become a mass without light, like its accompanying planets. According to Hoyle and Lyttleton, there should be thousands of planets scattered in space, derived from *supernovae* that were once members of *binary systems*. There seems no reason why many of these might not contain life in many ways similar to life on our own planet. But that is not a subject upon which we need to speculate here.

Later Stages in Organic Evolution

Factual records of events which happened in the distant past of the earth's history are detected by the geologist who studies the rocks. But even the oldest rocks which contain definite traces of fossil organisms, which are at least 500 million years old, already suggest that conditions on the earth's surface were then not very different from what they are today. There is, for instance, no clear indication even from the earliest known sedimentary or other rocks that the climate of this planet was at any stage very different from what obtains in our times. Indeed, all the evidence points to the fact that the physical phenomena called weather, were on the whole not less or greater in intensity in past geological times than are similar phenomena today. The rain fell as fast and furious or as gently as it does today, the ice formed under identical conditions, the wind swept past at the same speed as now, even though its prevalent direction might have been different owing to geographical differences.

To return to our subject. In the aforementioned 'family tree' (Fig. 1), in which unicellular organisms figure at the base of the stem and mammals (including the most highly evolved among them, the Primates) form the topmost branches, each group is derived from a more primitive one that precedes it. *This is*

also the order of their appearance in geological history. This fact, as we shall see later, is of great importance, and has been deduced not only from a study of the succession of rocks found in different parts of the world, but also from a careful and critical investigation of the life-histories of different living animals, commencing with their embryonic stages. Indeed our conceptions regarding our relationship with such primitive forms as the lancelets, sea-urchins, coelenterates and the protozoa, are based almost entirely upon embryology. To this we shall have to revert later, as it is the very foundation of the study of evolution.

After the reptiles had given rise to the mammals, probably in Permian times, (the earliest *known* mammal, which incidentally is non-placental, dates only from the Upper Trias, say about 160,000,000 years back) there arose among the mammals, sometime between the Cretaceous and Eocene, a peculiar group of animals. This comprised none other than the tree-shrews—squirrel-like insect-eating mammalian forerunners of man and of the other Primates Indeed, as the result of recent research, they are now included in the Primates themselves. These were preceded by the shrews or hedgehogs, whose modern representatives seem but little different from their Cretaceous forefathers, fossil remains of which have been recovered from the Gobi desert in Mongolia. From the tree-shrews arose in early Tertiary times (about 60,000,000 years ago), the Tarsioidea. These quaint little, jumping and tree-inhabiting animals have generally been regarded as the forerunners of the higher Primates, in which group scientists have included not only all the varieties of lemurs, monkeys and apes but man himself. It was from among these Primates that there arose, in course of time and by gradual evolution, a great variety of beings—half ape, half man—followed by others successively more man-like than their predecessors. Thus numerous types of apes like *Sivapithecus* and *Dryopithecus*, met with in the Siwalik rocks of India and in Europe, and the interesting *Australopithecus*, a man-like ape from Africa (regarded by some as a sub-man) came into being. These finally culminated, along one line, in Nature's most domineering and egotistic product, modern man or *Homo sapiens*, the 'wise' as his scientific name calls him, ironically enough. Along other lines, similarly, evolved *in succession* other types of Primates—the lemurs, the tailed

monkeys of the New and Old Worlds, the small anthropoid (man-like) apes such as the gibbon, and the large apes such as the gorilla, the chimpanzee and the orang-utan. The groups to which man and the modern apes respectively belong, however, arose from a common ancestor so that the apes are to us not in the relation of father and son (so to speak), but of cousins. And this close kinship is expressed in the striking similarity between their embryos (Fig. 4), besides a host of other characters.

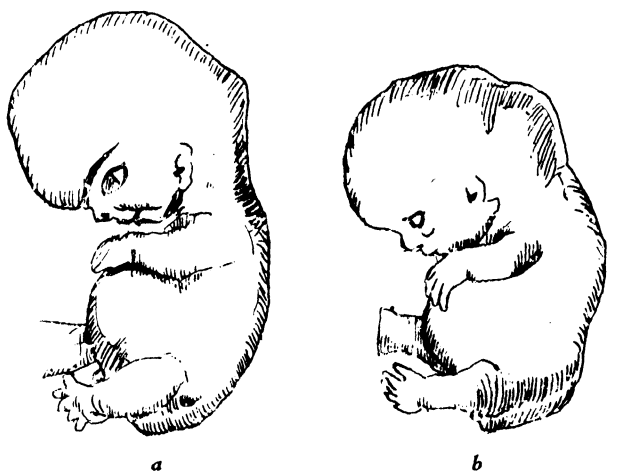


Fig. 4. Illustrates the similarity between the human embryo and that of another Primate, lower in the scale of evolution, suggesting their common ancestry. *a*, embryo of man; *b*, of gibbon, one of the smaller apes. Note particularly the presence of a tail in both. In still earlier embryonic stages of man (cf. Fig.87*a*) the tail is even more prominent. (After Selenka-Keibel).

There is yet another theory about the origin of man which involves the various human races. It is too fanciful to merit serious consideration. According to it, man in his diversity would not have originated from one common ape-like ancestor, but the three principal races, White, Yellow and Black would have arisen independently—the White race from some ancestor resembling the chimpanzee, the Yellow race from an ancestor similar to the orang-utan and the Black from a gorilla-like ancestor. So that the human race would not merely have imbibed the qualities of one type of ape, but of three of its distinguished relatives! This view is, however, flatly contradicted by fossil

or palaeontological evidence and is mentioned here only because of its humorous implications.

Whatever may be its more recent ancestry, this much is certain : that the Class to which man belongs—the mammals—has the reptiles for its 'father', the amphibians for its 'grandfather', the fishes for its 'great-grandfather', the lancelet-like forms for its 'great-great-grandfather' (not to mention the 'sea-potatoes' or 'sea-squirts' which are the 'great-great-great uncles'), the ancestral sea-urchin-like forms for a much greater 'great-great-grandfather', and so on. We shall in due course give as much proof as scientists have been able to establish, that the family tree as planted above is soundly rooted; that even the ancestry of those who suffer from the illusion of their exalted origin does not differ one iota from that delineated above.

But need we be ashamed of our animal ancestry? Or rather, should not our understanding thereof inspire in us a new effort, a new hope that, since we have succeeded in leaving the worm-like forms behind, we can still aspire to something much higher and nobler than man—perhaps a kind of superman who will not only be able to unmask the buried secrets of past aeons, but also to fathom the unborn mysteries of the future, enabling him to mould the destiny of the human race provided of course, the atomic bomb does not interfere in an untimely manner ?

Early Hindu Ideas on the Sequence of Life Groups

Ideas concerning the *relative* order in which the various animal groups arose appear to have been vague or non-existent in early times the world over. The ancient Hindus, however, seem to have established a fairly accurate sequence of the origin of various groups of living beings. At all events they believed, as modern scientists do, that life probably began in the water and that fishes, amphibians and land animals followed in succession. This can be seen from charts[1] which can be purchased even today in picture shops, illustrating early Hindu mythology, reflecting their concepts about evolution.

[1]These charts represent different phases of evolution—*machh avtar* (fishes), followed by *kachh avtar* (amphibious reptiles, like the turtle), *narsimh avtar* (representing land-living mammals), etc. It will be noticed that the amphibians proper are missed in the above sequence, though in regard to the succession—purely aquatic forms giving rise to amphibious forms and these last to purely land-living forms, the sequence adopted in these charts is broadly correct. (Hindi: *machh* = fish; *kachh* = turtle; *narsimh* = 'man-lion'; *avtar* = 'incarnation').

But their ideas about the origin of man and woman are even more practical than those held by the ancient Babylonians, the Jews and the Christians who, although they rightly placed the creation of man last in the order of living beings, yet believed that God had to take some clay, instead of an ape-like form, to make man from. Is this perhaps a suitable allusion to man's low moral qualities? However this may be, it is worth while to quote an adaptation from Lewis K. Hill, describing the Hindu legend which includes an interesting alternative for the origin of the woman from Adam's ribs, as contained in the religious legnds of Western Asia. He writes under the caption, "From the Beginning of Time":—

"In the beginning of time, says an old legend from the Sanskrit, the god Tvashtri created the world. Out of the elements he created the sun and moon and stars, the hills and forests, and finally man himself.

"All the solid elements were exhausted in the creation of man. So, when the time came to fashion woman, Tvashtri took the roundness of the moon, the curves of the creepers, the clinging of the tendrils, the trembling of the grass, the slenderness of the reed, the velvet of flower, the lightness of the leaf, the quick glance of the fawn, the brightness of the sun's rays, the tears of the mist, the inconstancy of the wind, the timidity of the hare, the vanity of the peacock, the sweet of honey, the cruelty of the tiger, the warmth of fire, the chill of snow, the chatter of the jay, the cooing of the turtle dove.

"All these he combined to make woman. And he gave her to man. And man's days were filled with happiness, for now he had someone to share with him the pleasures of the world.

"In the course of time, however, the man came to Tvashtri, saying, 'Lord, this creature that you have given me makes my life miserable. She chatters incessantly and teases me beyond endurance, never leaving me alone. She requires incessant attention and cries about nothing and is always idle, so I have come to give her back again. I cannot live with her.'

"So Tvashtri took her back. But eight days later, the man was at Tvashtri's door. 'Lord,' he said, 'my life is lonely since the woman has gone. I remember how she danced with me, and how she laughed and filled my heart with pleasure. I remember how she clung to me, and how sweet and comforting

was her presence when the sun went down, and the darkness surrounded me.'

"So Tvashtri returned the woman, but a month later the man again importuned him, 'My Lord,' he said, 'I cannot understand it, but I am sure the woman causes me more annoyance than pleasure. I beg you, Tvashtri, to take her away again.'

'Go your way and do the best you can,' Tvashtri answered.

'But I cannot live with her,' the man protested.

'Neither,' said the god, 'can you live without her.' "

And thus man and his fair counterpart came to be.

CHAPTER II

THE GEOLOGICAL TIME-TABLE

Comparison between Geological History and Human History

IN ORDER to place the subject of man's evolution in its true perspective, it is desirable to give the basis upon which the geologist founds his chronology or time-divisions, and to explain how he deciphers geological history, spanning time-intervals which baffle the imagination of man. This will also enable the reader to gain a clearer concept of the stages through which man has passed during the course of evolution, of the antiquity of the human race, and of its place relatively to that of the other groups of animals in the geological time-table. Incidentally we shall be able to elucidate the terms Trias, Cretaceous, Tertiary, etc., indicating subdivisions of geological time, which we have been using without adequate explanation in the foregoing chapter.

As will presently appear, there is a remarkable similarity between the criteria by which the geologist separates his time-intervals or geological periods and the historian his historical periods. Let us explain.

You must have often seen along valleys and hillsides, layers of rocks or strata, resting one upon the other. Now it is one of the fundamental principles of geology that, unless the strata have been disturbed by natural forces (which has very often happened), each bed of rock is younger in age than the bed it overlies; that is, it was deposited later in time. The beds may contain fossils, which are the remains of the animals and plants that lived during the period when these strata were being deposited, whether on land, in the open ocean, fresh-water lake, lagoon or land-locked sea, or other environment. These fossils record the geological conditions of that period, its climate and physical environment, for we know the present-day environments in which similar and closely related animals are living. They are, in fact, comparable to inscriptions and other records which the historian finds in ancient monuments, or to buried cities, and which help him in writing the history of the age to which

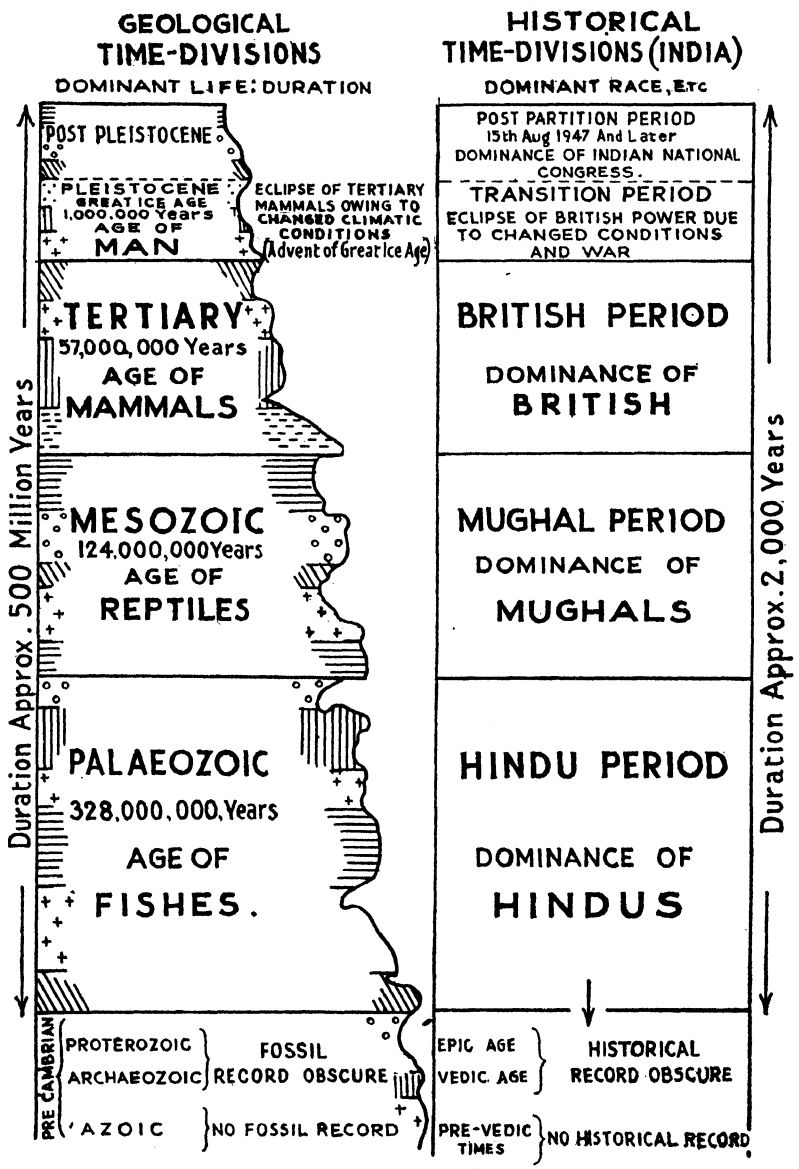


Fig. 5. Illustrates the general parallelism of criteria upon which geological and historical time-divisions are based. Not to scale

the monument belonged, or in which a particular city flourished. Each one of these strata is thus comparable to a leaf or even a chapter out of a book of history. Even the mineral content of these strata helps us in revealing the physical history of the period when they were being formed. There is, however, one difference, that while historical records are very often biassed and therefore liable to misrepresent the truth, fossils or minerals, having no caste, creed, colour or nationality, are impartial and honest, though sometimes puzzling documents. A German fossil mollusc is no more a Social Democrat than one from Indian soil or from Pakistan has leanings towards any particular denomination ; nor will a British cockle-shell necessarily vote for the Tories or a Spanish one for the most charming Señorita. The facts of palaeontology and geology are, therefore, untainted truth, immutable and unalterable, and geological history is in this respect more authentic and less liable to misinterpretation than the history of historians.

The simile between human history and geological history may be carried further. It is well known that the reigns of various monarchs or dynasties or the advent of great historical events, like the rise of Ashoka's empire in India, the Renaissance in Italy, the American War of Independence, the Russian Revolution, the birth of the Indian Republic, serve to subdivide historical time into periods by interrupting existing historical progression. Now in precisely the same manner, the advent or extinction of certain animal or plant species, whose remains are preserved in ancient rocks as fossils, coupled with various geological events which interrupt the continuity of deposition of strata or of other geological processes, constitute landmarks in historical geology and serve as the basis for geological time-divisions. Such events are, for example, the uplift of an ocean-bed, or submergence of continental regions, or even the advent of glacial conditions, as at the commencement of the Pleistocene. If the commencement of a new historical era is marked by the replacement of one great ruling dynasty by another, or by a political revolution, the beginning of each geological period is likewise marked by the extinction or decline of animal groups which may have lived through millions of years; by the simultaneous ascendancy of other groups; or by physical revolutions

of the globe involving extensive readjustment between land and sea.

A Parallel from Indian History

Since this matter is of fundamental importance, let us take a parallel from Indian history. In the manner in which the Indian historian defines the Hindu period, the Mughal period, the British period, each characterised by the political dominance of a certain racial group; so we have in historical geology the time-divisions : the Palaeozoic (or Primary), the Mesozoic (or Secondary), the Cainozoic (or Tertiary), progressing into the Pleistocene and Recent, each characterised by the dominance of certain animal groups—the fishes during the Palaeozoic, the reptiles during the Mesozoic and the mammals during the Tertiary (Fig. 5).

The parallel fits to the last inch and, just as the historian finds the historical record becoming more and more obscure as he recedes into the dawn of history, so the geologist has to grope for clearer evidence in the haze of antiquity, far back in the fabulous depths of time. The reader will thus see that the geologist separates his time-divisions in much the same manner as the historian does his. But with one more difference—that the historian has to deal with only about 2,000 years, whilst the geologist has to account for something like 500 million years since life began; about 2,000 million years since the commencement of the Archaeozoic or the era of primaeval life, and 3,000 million years since the Azoic (lifeless) era, taking us to the time prior to the formation of the earth's crust, which figure might be taken as the age of the earth. If years could make him, alas, every geologist would be a millionaire many times over !

Furthermore, if the historian can reconstruct the manners, social customs, form of government, and general conditions of a particular historical period from contemporary records, the geologist can equally determine from a study of the fossils and rocks found, the geography, climate, and temperature of that region; he can even estimate the depth and degree of salinity of an ocean which existed millions of years ago. He can tell whether at any particular period of the earth's history a certain part of the globe was a desert or covered by ice or was an ocean bed ; and this, when all the evidence available is no more than

a bed of shale—a heap of dust, unscented. We do know, for example, that during the Jurassic period the region of the present North Pole had a tropical climate and supported thick forests; that during the early Gondwana period, the South Pole was situated in the middle of the Indian Ocean, while the North Pole lay in the neighbourhood of Mexico. It is also thought that the North Pole, which lay in the region of the North Pacific during the earlier part of the Tertiary era, say about 50 million years ago, finally shifted, towards the close of the era, perhaps less than 5 million years ago, to where it is today. This shifting of the Poles may have been connected with the uplift of the regions comprising Canada, Scandinavia and Greenland, parts of which in fact now constitute the North Polar zone. Likewise it is common knowledge that the island of Great Britain suffered a tilt, for while its northern part was uplifted 100 ft. or more as the result of the removal of the load of ice which lay on these isles during the Great Ice Age, Southern Britain did not rise at all.

The geologist can tell from a study of fossils and the structure of rocks whether a great continent has foundered and disappeared into the bowels of the earth, or whether, by a reverse process, a continent has been born anew, and emerged from the ocean-depths. A single fragment of a fossil is enough to tell us that the beautiful highland of Gulmarg in Kashmir was uplifted in (geologically speaking) recent times, for the remains of plants and shells found in the Karewa deposits, seen over the golf course, definitely indicate a much warmer climate and therefore lower altitude than that at which Gulmarg lies today. It further tells us that the great Himalayan mountain range emerged from the Tethys sea when the ancient continent of Angaraland, which lay to the north of it, pressed the sea-bottom against the stable Indian Peninsular land-mass (a *horst* in geological parlance), and uplifted the soft sediments deposited in the sea-bed to an extent of 16,000 ft. and more, above sea level ! And the Himalayas are still rising, though at an infinitesimal rate.

METHODS OF TIME-ESTIMATION : THE AGE OF THE EARTH

Figures in respect of the antiquity of the various races of living beings are truly staggering, though not even a paltry

million years have elapsed since the *known* advent of man on the earth. The earliest mammals appeared about 160 million years ago (Upper Trias); the reptiles about 210 million years ago (Upper Carboniferous); the amphibians at least 250 million years ago (Lower Carboniferous), or if we take into account the footprint of *Thinopus*, about 260 million years ago (Upper Devonian); the first known (jawless) fishes about 380 million years ago (Upper Ordovician), while considerably more than 500 million years have passed since the first dawn of life upon the earth[1]. If these figures are out by a day or two we must ask forbearance of the Shades of our noble fossils for we have no desire to upset their claim to ancient lineage. Nor must the reader feel bewildered if he finds apparent discrepancies between these estimates and the figures given in other publications, for there is as yet no finality about many of them, and estimates vary.

The figures given above are the minimum figures, so that at least 500 million years have elapsed since life first appeared. But how much further life's record extends into the still more remote past may never be known, for the ancient rocks which may have contained these remains have suffered so much from the effect of pressure, heat and earth-movements, that all trace of organic existence has been obliterated.

Now, the reader will surely ask, How can the geologist prove these claims when he talks so glibly in terms of millions of years, as if a few million years are of as little consequence as three score minutes to the man who habitually walks late into office as a matter of right and routine ?

We are in duty bound to satisfy the reader's curiosity. But before we proceed, let us clarify what exactly we mean when we speak of the age of the earth. It is obvious that there is no such thing as the absolute age of this planet, because there is no precise date, year or even century when the earth was born, in the sense that we ordinarily understand it. Indeed, we are uncertain even as to the manner of her origin. So that all we can determine is the ages of the different strata whenever evidence is available; or we can determine the antiquity of the era in geological history when life began, which again probably covers several million

[1]It is necessary to emphasize here that the various figures given above should be regarded as approximate, for although we know the durations of the major geological periods, dating of events within their subdivisions must be somewhat arbitrary, except where determinations are based upon the radioactivity method (p. 26).

years, for we cannot decide when exactly life first appeared. Or else we might fix the period when the first deposition of aqueous rocks took place, though it is often wellnigh impossible to recognise them as such, owing to the vast changes they have undergone subsequent to their deposition.

These are not the only difficulties.

Lest we may appear to make a bigger claim than is warranted by facts, we would like to make it clear, that *no method of estimating geological time has yet been found which is mathematically exact.* All the methods we know of, yield results that can be easily off the mark by a few million years. What we can say is that we seem to be on the right track, and with the rapid advance of science, the methods may ultimately be improved so as to enable us to establish a reasonably accurate geological calendar, even if we cannot tell with precision whether the birthday of a certain Dinosaur fell on a Wednesday or a Saturday morning, in the year 100,000,000 and odd B.C.

There are several methods of estimating geological time, some of which are described in the following paragraphs.

The Geological Method

This method is the simplest and it was one of the earliest to be employed in determining the ages of rocks. But it can be applied only to aqueous sediments, that is, those deposited in water.

The geological column divided into different subdivisions (see Figs. 2 & 5) is composed of strata of which the total thickness can be obtained by measuring sections (of these strata) exposed in different parts of the world, and by adding up the figures. Now if we were able to determine the average rate at which such sediments are being deposited annually today, we could, by the simple rule of three, calculate not only the durations of the smaller subdivisions, but also of the major geological eras, the Palaeozoic, the Mesozoic, the Tertiary and the Pleistocene, and eventually the age of the earth, that is, its antiquity since deposition began. This has actually been done; for we have been able to measure the quantity of sediments brought down annually by the rivers and deposited in the oceans. Since the rate of deposition is known, the time taken in deposition

can be determined, for we can safely assume that this rate was the same in past geological times as it is today.

These calculations give a total discharge of 20,000 million tons of sediment annually and the total (maximum) thickness of strata about 70 miles (in round numbers) for the whole geological sequence as given below, following Zeuner :—

PERIOD	THICKNESS
Pleistocene	4,000 ft.
Pliocene	18,000 ft.
Miocene	21,000 ft.
Oligocene	15,000 ft.
Eocene	23,000 ft.
Cretaceous	64,000 ft.
Jurassic	22,200 ft.
Triassic	25,000 ft.
Permian	18,000 ft.
Carboniferous	40,000 ft.
Devonian	37,000 ft.
Silurian	20,000 ft.
Ordovician	40,000 ft.
Cambrian	40,000 ft.
TOTAL THICKNESS	387,200 ft. =73 miles, approx.

This method however yields estimates of time which certainly cannot be accepted today and are only of academic interest. This is due to the fact that the method has several limitations. Firstly, it is impossible to estimate accurately the total thickness of rocks in a particular subdivision. Some strata are bound to escape detection because no subdivision is represented in its entirety in any one locality, or even in any one country, and one has to complete the measurements by collecting data the world over, as in the above Table.

A second difficulty is that strata are not deposited in one continuous succession, but there are frequent breaks in deposition—*unconformities* as the geologist calls them—which sometimes cover millions of years and which have thus to be accounted for. Sometimes, of course, these gaps can be filled, for such breaks are not in all cases universal. This means that strata representing a gap in one locality or one country might be found in other regions.

A third difficulty is that the thickness of the ancient rocks, as we see them today, cannot be their original thickness; for, as a result of compression due to earth-movements and the weight of overlying strata, this must have appreciably decreased. Further decrease in thickness must have resulted from their extensive weathering and denudation. Consequently, the method of time-estimation based upon thicknesses of strata gives us only the minimum and not the actual, or maximum, age of these rocks. And, in any case, as we have already stated, this method applies only to strata deposited in the water and gives no information about the age of thousands of feet of volcanic rocks which remained molten during cosmic time[1] and which constituted the primaeval floor upon which the former were deposited.

The Earth as a Cooling Mass

Towards the end of the last century the distinguished physicist, Lord Kelvin, attempted to estimate the age of the earth by determining the time it should have taken to attain its present temperature, assuming it to be a cooling body. According to his calculations, into the details of which we need not enter here, he came to the conclusion that the process of cooling could not have begun more than 20 million years back and therefore this figure represented the age of the earth. (His maximum figure was 400 million years which he did not accept). His method took no account of the repeated glaciations experienced by the globe which suggested, contrary to assumption, that the rate of cooling had been scarcely uniform. Nor did he consider the influence of radioactive radiation. For these reasons, the result was an obvious under-estimate. We know that it was almost exactly one hundred times less than the figure which had been actually determined by other methods for some of the oldest-known (Pre-Cambrian) rocks of the earth, namely about 2,000 million years.

How has this awe-inspiring figure been arrived at ? What is the experimental basis upon which it is founded ? And why were Kelvin's calculations so low ? These questions are answered in the following paragraphs.

[1]Cosmic time may be said to represent that vast interval during which the earth was still in a molten or semi-molten condition. We have scarcely any conception of its duration.

The Radioactivity Method

The main reason for this wide discrepancy was not known in Kelvin's day. This was the presence within the earth, of radioactive minerals like radium, first discovered by the Polish scientist, Madame Curie, in 1902. Though it is true that the quantities of radioactive minerals found in the earth's crust are extremely small, yet they have an enormous cumulative effect. Indeed, another physicist, Rayleigh, calculated that the disintegration of these small quantities of radioactive minerals would produce sufficient heat to compensate in part for the cooling of the earth and that this would easily account for the wide discrepancy between the results obtained by his predecessor, Lord Kelvin, and the present-day estimates.

It is the energy locked up within these radioactive minerals that is being utilised for atomic bombs. And this energy derived from the fission of the nucleus or core of an atom is so colossal as to surpass all human imagination. Thus the splitting, or 'nuclear fission', of a single atom of uranium lets loose an amount of energy which is 200 million times the energy necessary to split that atom. And when it is realised that there are 100,000,000,000,000,000,000,000 atoms in an ounce of uranium, the heaviest mineral so far known, the result of the explosion of a mere pound of Uranium ^{235} which yields explosive energy equal to that of about 10,000 tons of TNT, one of the most highly explosive substances so far known, can well be imagined—or not.

Small wonder then that one atomic bomb, containing a comparatively small quantity of radioactive substance has devastated a big town and either killed or permanently disabled 80,000 persons in the twinkling of an eye. And it is said that there are enough atomic bombs today in the possession of civilised, freedom-loving, humanitarian nations of the world to wipe out its entire population if suitably and conveniently placed ! Little did Madame Curie think what her singular discovery might lead to. Little does humanity realise what it is going to lead to. But personally we are all in favour of starting with a clean slate, for the world-picture has become so confused that it is going to be difficult to rectify it !

To come back to our point: measurement of geological time with the aid of radioactive minerals appears to be the most

reliable method so far discovered; but even this is not mathematically exact, and, in any case, we have no means of checking its absolute accuracy. However, we know that this method does give us the correct *relative* ages of rocks. Thus the ages of Palaeozoic rocks deduced by the radioactive method are greater than those of Mesozoic rocks, while those of the latter are in turn greater than of the Tertiary rocks—a fact we definitely know from purely geological data. It is, therefore, clear that we are on the right track, and if our results are still inaccurate, this might be ascribed to normal errors of experiment.

It is known that radioactive elements like radium, uranium and thorium disintegrate into successively simpler elements of smaller atomic weight, and that this change goes on continuously till a stable substance is formed, and no further disintegration is possible. In the case of uranium, the stable substance is lead. This end-product is formed after eight atoms of helium gas have been lost from the uranium atom. It is assumed that after their genesis, both helium and lead remain entrapped within the parent rock, so that we would know the relative quantities of uranium, helium and lead present in the rock.

Now the rate at which this disintegration takes place, though slow, has been accurately determined. It is also known that the rate at which uranium changes into lead, as a result of the discharge of helium atoms from it, is constant, and that in all uranium-bearing minerals derived from rocks of the same geological age, the ratio of lead (Pb) to uranium (U) is likewise constant. It thus follows that if in any rock containing a uranium-bearing mineral the ratio of lead to uranium (Pb/U) is known, the age of that rock can be determined by a simple equation.

As the matter is of exceptional interest it may be worth while to give some details in a form which, we are sure, will not be too technical even for the layman.

It is known from actual experiment that

One gramme of uranium yields annually	$\frac{1}{7,600,000,000}$	of a gramme of lead
At this rate, U grammes of uranium will yield	$\frac{1 \times U}{7,600,000,000}$	grammes of lead in 1 year
In T years they will yield	$\frac{T \times 1 \times U}{7,600,000,000}$	grammes of lead

Therefore the amount of lead (Pb) produced by a given quantity of uranium, U, in T years can be denoted by the following equation :

$$Pb = \frac{T \times U}{7{,}600{,}000{,}000}$$

This means that T, or time taken in number of years to produce this quantity of lead

$$= \frac{Pb}{U} \times 7{,}600{,}000{,}000 \text{ years}$$

Therefore when the lead-uranium ratio (Pb/U) in any uranium-bearing crystal is known, we can determine T, which stands for the time in number of years since this crystal was formed; that is, we can determine the age of the crystal and *ipso facto* the age of the rock in which the crystal originated.

It is obvious that even this method cannot be exact, as we have to make two assumptions, which may or may not be justified. Firstly, we assume that the uranium-bearing mineral present in the rock was introduced into it *at the time of its origin*, and, secondly, that none of the helium or lead resulting from the disintegration of the uranium has escaped. Bearing these limitations in mind, the durations of the major geological subdivisions or eras, deduced from radioactive determinations, are as given below, in round figures :—

GEOLOGICAL TIME-DIVISIONS	DURATIONS	
Quaternary or Great Ice Age	0 to 1,000,000	years.
Tertiary	1,000,000 to 60,000,000	„
Mesozoic	60,000,000 to 180,000,000	„
Palaeozoic	180,000,000 to 500,000,000	„
Proterozoic	500,000,000 to 1,000,000,000	„
Archaeozoic	1,000,000,000 to 2,000,000,000	„

To give more precise figures, the oldest rocks are reported to occur in Huron Claim, Manitoba, Canada, and give an antiquity of 1,985 million years, or say, two thousand million years in round numbers. The origin of the earth might date back 3,000 million years or more.

It will further interest the reader to know that the age of the oldest known meteorites (those bright, fleet-footed messengers that visit our planet now and then from the worlds beyond) has been determined upon this basis to be 6,800 million years.

Age-Determination by Radiocarbon Content

We may refer here also to the Radiocarbon method. Though this is not likely to be applicable to time earlier than the late Pleistocene, it is, nevertheless, of value to archaeologists in dating the late Stone Age industries when these are associated with fossil bones. The fundamental basis of this method is that ordinary carbon C^{12} has a radioactive isotope C^{14}. This isotope is derived from nitrogen by the action of cosmic rays at high altitudes and is known to occur in carbon dioxide which is assimilated by plants, together with the radioactive isotope. After C^{14} enters into the composition of the plant, it changes into nitrogen, the proportion of C^{14} to C^{12} decreasing at a known rate. The half-life period of C^{14} is about 5,720 years. These data give us a basis for measuring age. However, since the quantity of C^{14} in the plant is of an infinitesimal order, this method can only be used provided sufficient fossil material or wood and bone remains, such as occur in kitchen middens, are available. There is reason to believe that age-determinations for the last 30,000 years are possible by this method.

The Astronomical Method

In recent publications of great interest, the distinguished geochronologist Zeuner, has given a lucid exposition of the various methods for the estimation of geological time. Among these he draws particular attention to the astronomical method of dating the climatic fluctuations which occurred during the Pleistocene. This method is based on the slight changes in the position of the earth and other phenomena, summed up under the term, *Perturbations of the Orbit.*

The 'perturbations' upon which the astronomical method is based, are changes in the eccentricity of the earth's orbit, the inclination of the earth's axis (obliquity of the ecliptic) and the precession of the equinoxes. This last 'perturbation' is a "slight conical movement of the earth's axis. It results in a slow shifting of the *cardinal points* (spring equinox, summer solstice, autumn equinox, winter solstice), which delimit the seasons." As a result of these 'perturbations', the amount of solar heat received by the earth has varied in the past and caused lowering and raising of temperature. Although these changes are minor as

compared to the dimensions of the orbits[1], they nevertheless exert a profound influence upon the earth's climate, causing even ice conditions at intervals, such as during the Great Ice Age. It must be further emphasized that whilst the climatic fluctuations due to changes in solar radiation are not so appreciable when we take only annual changes into consideration, they are enormous when computations are made over thousands of years. And what is equally important, these 'perturbations' occur in cycles, that is, they possess a periodicity, which is 40,000 years for the obliquity of the earth's axis, 92,000 years for the eccentricity and 26,000 years for the precession of the equinoxes. These changes have been calculated for the past 1,000,000 years.

This method was used first by Adhemar (1842) and then successively with modifications by Croll (1863) and Ball (1890). However, the scientific foundation of this method was laid by three famous mathematicians, Lagrange (1782), Leverrier (1843) and Stockwell (1873), and it has achieved a considerable measure of success in so far as the last million years are concerned. It has not been possible to apply it successfully to more remote periods.

The *combined effects* of the 'perturbations' were calculated by Pilgrim, Milankovitch and Michkovitch, Stockwell and others. Their data have been compared with those obtained from purely geological methods, and a remarkable correspondence between the two has been found in the case of areas where the geological record is complete, a correspondence which is unlikely to be due to pure chance. This suggests that the solar radiation data provide a reliable index of absolute age.

For the purpose of dating, only changes in the radiation received in summer are, as a rule, considered for it is argued that the summer heat was largely responsible for the melting of the ice during the Ice Age. The geographical latitude has to be considered also, a fact which was neglected by earlier workers in this field and which led to the refutation of their views. For example, 10,000 years ago the amount of summer radiation

[1]The path of the earth around the sun (orbit) was sometimes a very flattened ellipse and at others almost a circle. When the orbit was a very eccentric ellipse, the earth was far removed from the sun for long periods and, therefore, received much less heat (thus contributing towards ice-conditions) than when the orbit was sub-circular. Astronomers have determined that there is a periodicity in these phenomena.

received by the 65th degree of northern latitude equalled that received by 60° N today. But the summer radiation received by the same latitude 230,000 years ago was far less, equalling only that now received by 77° N. Furthermore, one finds that the sequence of minima of summer radiation in the curve for N. lats. 65°, 55° and 45° shows a remarkable correspondence with the successive glacial periods in Europe as determined by the geological method. This will be obvious from the radiation curve for the last 600,000 years, which period covers the various phases, Glacial and Interglacial, of the Great Ice Age. Counting before the present time, the radiation curve shows three summer minima between 25,000 years and 115,000 years, preceded by normal conditions which lasted for 60,000 years. Prior to this, there were two minima at 187,000 and 230,000 years, preceded again by a long interval of 190,000 years, corresponding to the Great Interglacial when normal conditions again prevailed. Still earlier, we find two minima at 435,000 years and 476,000 years, preceded by normal conditions for 60,000 years, and again two minima at 550,000 years and 590,000 years.

There is not only a close correspondence between the radiation data and the chronology of the Pleistocene (which is significant) but even the durations of its various subdivisions, as determined by the glaciologist Penck, give remarkably similar values. These were based upon the rates of deposition of fluvio-glacial gravels left by sheets of ice. He and Brückner (1909) also determined the durations of the Interglacial periods by the amount of erosion suffered by these glacial deposits. The value of Penck's work is enhanced by the fact that his conclusions were arrived at independently, for at the time he made his calculations he was not aware of the radiation data. Penck's figures compared with those derived from radiation data are as follows :—

Periods	Durations based on Geological data	Durations based on Radiation Curve
Time since third climax of Last Glacial	16-24,000 years	22,000 years
Third Interglacial	60,000 „	60,000 „
Second Interglacial	240,000 „	190,000 „
First Interglacial	60,000 „	60,000 „
Pleistocene	600,000 „	600,000 „

These figures are in sufficiently good agreement to be accepted

as a basis for the dating of the Pleistocene, that is, of the period of man's existence on the earth. They provide what one might call a 'skeleton chronology'. An object like a fossil bone or a prehistoric tool can, however, be dated by the astronomical method only if the climatic phase of the Pleistocene to which it belongs is exactly known. Generally speaking the astronomical method is providing us with the necessary subdivisions for the last million years which the radioactivity method cannot.

It may be noted that though the duration of the Great Ice Age as given above is 600,000 years, for all practical purposes a duration of 1,000,000 years is accepted to include the lower subdivision of the Pleistocene, the Villafranchian (see p. 103).

The Glacial or Varve Method

The varve method is essentially a variety of the geological method and like it, has only a limited application. It is based upon the fact that sand and mud are carried by streams issuing from the ice fields and are laid down in ponds and lakes nearby. But the coarseness of the material transported varies with the season. Thus bands of coarse material are laid down in the lakes during summer when there is a great quantity of water in the streams owing to melting of ice and when its flow is rapid. These coarser bands alternate with fine clays or silts deposited during the winter when there is scarcely any water in the streams and the fine material suspended in the water has sufficient time to settle down. These alternating annual layers of silt and sand are known as varves. During the Ice Age, the process of varve formation was repeated year after year, century after century, varying perhaps in intensity, but always producing the same result—coarse bands alternating with finer silts and clays, *each pair of bands (varves) representing a span of one year.* The Swedish geologist, De Geer, counted the number of such glacial silt bands in Scandinavia. On the basis of these counts and other relevant data he estimated that the time which had elapsed since the Fourth and last ice sheet began to melt was about 18,000 years.

As in the case of the geological method, there are serious limitations. Firstly, some of the finer bands are likely to be missed in the counting and, secondly, denudation may have, in fact must have, removed some of these layers. The countings of even the most complete series therefore give us *minimum* figures only.

The Indian reader will be interested to know that such varve formations are exposed along the footpath which descends from Gulmarg and skirts the northern flank of the hill facing the vale of Kashmir. These varves bear testimony to the former extension of ice in this region. Indeed there is sufficient evidence to indicate that there were three distinct periods of ice advance and retreat in parts of Kashmir during the Great Ice Age. This subject has been dealt with in greater detail in a later chapter.

Dating by Tree-Ring Analysis (Dendrochronology).

It would be appropriate to refer here to another method of age-determination, based upon tree-ring analysis. It relies on cycles of the year and sun spots. These affect the growth rings of trees which are the result of seasonal variations, each tree-ring representing a year. Each of these rings is composed of large, thin-walled cells added in the spring and smaller, thick-walled cells formed in the summer. Since all trees of a particular area are affected in the same way, it is obvious that the outer growth rings of young trees would correspond to the inner growth rings of older trees. This gives us a method of correlating the two. Going backward, correlations can be made between modern trees and timber found in prehistoric sites or other buildings. A count of tree-rings of such a series gives us, after careful interpolation, the age of the historic or prehistoric timber and of its associated remains. This method has serious limitations, however, for it can apply only to the last two or three thousand years. It can, therefore, at best, be of some value in dating historical events or the later prehistoric phases. For details the reader should consult the publications referred to in the bibliography.

Determination of the Age of the Ocean from its Salt

Another interesting method of determining geological time, more exactly the time since deposition of strata first began, is by measuring the rate at which the oceans acquired their salinity. It is assumed that all the oceanic salt was derived from the earth's original crust, for rain-water does not contain any. Now if we know the total quantity of salt in the oceans and the quantity of salt discharged annually into them by the rivers, the time taken by the oceans to acquire their present salinity can be calculated by simple division.

It has been estimated that the total salt in the oceans is of the order of 4,500,000 cubic miles, which means about 16,000,000,000,000,000 tons of sodium[1], to take only one component of salt, in order to simplify calculation. The quantity of sodium discharged annually into the oceans by the rivers has been measured and is known to be 158,000,000 tons. Thus the time that has elapsed since deposition first began, is:—

$$\frac{16,000,000,000,000,000}{158,000,000} \quad \frac{(\textit{Total sodium})}{(\textit{Annual addition of sodium})} = 101,265,000 \text{ years.}$$

This figure, however, does not agree with the age deduced from the lead-uranium ratios, due undoubtedly to the fact that salt is incorporated in the deposits and, though subsequently redissolved, it forms no permanent addition to the oceanic salt. There are other factors, but we cannot enter into further details here.

To sum up : the various methods employed to determine the age of the earth have yielded such divergent results as to leave scarcely any doubt that the premises upon which some of them are based are not sound enough and that there are complicating factors which, from the very nature of the problem, we have been unable to take into consideration. In particular, the methods based on the rate of cooling of the earth and on quantitative determination of oceanic salt are unsatisfactory. On the other hand, the determination of the age of the earth by means of radioactive minerals is so far the most reliable way.

[1]Common salt is composed of two elements, sodium and the gas chlorine, its chemical formula being NaCl, where Na stands for sodium and Cl for chlorine.

CHAPTER III

IDEAS OLD AND NEW

The Layman puts a Question or Two

EVEN the man of science groping through the haze of antiquity, through a labyrinth of often indistinct evidence, piecing together scattered remnants of fossil bones, looking for a clue here, a clue there, has but an imperfect knowledge of his own origin. It is, therefore, not surprising that the layman has ideas and queries of his own. There must be few geologists or palaeontologists who have not been faced with questions like these :

"What is a fossil?"

"When did life first appear on the earth?"

"When did man appear?"

"What are stone implements?"

"Has man descended from the apes?"

"How has he lost his tail?" and so on.

A brief reference to some of these questions has already been made in the foregoing pages. But if the layman is certain of anything, it is that man did once possess a fine tail, which he has managed to get rid of somehow or other, and this is the aspect of his existence he seems to feel most anxious about. While we shall deal with this interesting problem in some detail in a subsequent chapter, we may here first enquire what exactly is a *fossil.* For it is around fossils that the entire story of evolution is woven. Furthermore, the idea of evolution was developed gradually, and it will be worth while to enquire about the changes through which the concept of evolution has passed.

What is a Fossil ?

To the ordinary person a fossil is nothing more than an organic object that has turned to 'stone', but to the scientist it is much more than that. To revert to an historical simile, the difference is as between finding in a curio shop an ancient clay tablet with an inscription and discovering the same thing buried in an archaeological monument, a monument that may not only have

been erected to house the inscription but which was perhaps moulded out of the very same clay as the inscription itself. In short, in the latter case we are enabled to conclude that the inscription as well as the monument were contemporaneous, and we may even be able to determine the age of the one from the other, depending upon available data.

A fossil may likewise be described as an organic object coming from a plant or animal *that was alive at the very time when the rocks in which it now lies buried were actually being formed.* For instance, a shell which the waves throw on to the sea-shore where it becomes covered with sand at the very moment that you saw it being played about by the waves, is a fossil in a truer sense of the term than, say, bones of man that were artificially buried in strata that just happened to occur in the neighbourhood, and became fossilised therein. The shell fixes the age of the strata that entomb it and indirectly tells us of the physical conditions—climate, temperature, etc., that prevailed contemporaneously with it, whilst artificially buried bones do not (see p. 250). Thus according to the strict definition of an ordinary fossil, it is essential that the organic remains should have been *buried by contemporaneous natural processes.*

From the foregoing it should not, however, be concluded that human and animal remains found in artificial burials are of no importance, for they, too, throw valuable light on evolution, and in any case, remains of man and the higher vertebrates are rare enough not to be despised, whatever be their mode of occurrence. They, too, are 'fossils' but not generally contemporaneous with the layers that contain them, and it is often a difficult matter to determine their age.

Furthermore, it is not organic remains alone that are included in the term 'fossil', but even foot-prints or other impressions of animals and plants are regarded as such. By way of example, we may mention the impress of the first recorded terrestrial foot—that of the amphibian, *Thinopus* (Fig. 18), found in the Devonian rocks of America, to which reference has already been made. This archaic animal literally left its 'foot-prints on the sands of time' for we know the exact geological period, many million years past, when it took a stroll.

Usually what is left of the substance of the once living being, mostly its hard parts, has changed its chemical composition.

It will have turned into a substance like silica, or carbonate of lime, pyrites or 'fool's gold', etc. Bones have often been changed into kinds of phosphates other than those which originally composed them. In the process of fossilisation, certain chemical substances replace the original substance of the organic remains *molecule by molecule* so that even the minutest detail of structure—so minute that only the highest-power microscope can reveal it—is often preserved.

Very rarely remains of extinct animals have been found buried in the ice of the northern latitudes and in the asphalt deposits of the United States of America in so fine a state of preservation that not only the skin and hair, but also the flesh was there. Such was the case with the mammoth whose remains were found buried in the ice-fields of Eastern Siberia, near the banks of the Beresovka river. So perfect was the state of its preservation that the dogs accompanying the Russian hunter who discovered it made a meal of its trunk! And yet this mammoth is in the truest sense a fossil.

THE DEVELOPMENT OF GEOLOGICAL IDEAS IN THE WESTERN WORLD

The Early Greek Philosophers

In every age and every country men have arisen who were wiser and more observant than their fellow beings, and who by dint of intelligence and inspiration have sifted myth and romance from facts of history and science handed down the corridors of time, and have given the world knowledge which appears wonderful when viewed in retrospect. We may thus do justice by our past; for centuries ago our forefathers knew about the succession of Ages, the Stone Age, followed by the Copper Age, followed by the Bronze Age, followed by the Iron Age; and the eighteenth and nineteenth century scientists may be said to have merely rediscovered this sequence. Likewise twenty-three centuries ago, Aristotle, 384—322 B.C., revealed that the whales were to be classed with the mammals and not with the fishes; that the common bat, though capable of flight like a bird, was not a bird at all, but a mammal like the whale, which is thus no more a fish in the scientific sense of the term than your door-knob. This means that both the bat and the whale are more closely related to each

other and to man than to any bird or any fish; and the Greek sage who appears to have probed into the problems of evolution had established this more than three centuries before the Christian era. But Aristotle knew much more—he knew that the distribution of land and sea had not remained unchanged, that certain regions which are now dry land were once covered by sea and that parts of oceanic regions had been land areas. Earlier still, Herodotus, 484 (?)—425 B.C., observed the remains of marine shells in the deserts around the Mediterranean Sea proving that this sea had had a wider extent in past geological times. The great mathematician Pythagoras, 582—507 B.C., had however forestalled both Aristotle and Herodotus, having already arrived at similar conclusions. Have we not, perhaps, given ourselves more credit than is our due ?

European Ideas in the Sixteenth Century; Leonardo da Vinci ; Mercati

In Europe the first to suggest clear and correct views regarding the true nature of fossils was, strangely enough, the artist Leonardo da Vinci, 1452-1519. This genius was not only a great painter but he was also an engineer and sculptor of repute and the sun-lit plains of Italy owe some of their waterways to him. When engaged on engineering projects, he made his first acquaintance with fossils, the nature of which he correctly interpreted. In another field, the great Mercati[1] of the sixteenth century was the first to discover the truth about stone implements, and assigned human origin to them. Previous to this, stone implements like scrapers, axes, arrow-heads, etc., shaped by early man, were regarded as bolts from the blue, the result of lightning and thunder—mere playthings of nature.

The Cataclysmal Theory of Creation

When we compare the scientific marvels of the present, which might be called the Atomic Age, we shrug our shoulders at the ignorance prevailing only three score years ago. As we recede into history, the same story is repeated and marvels of yesteryears seem but the child's-play of today.

[1]Not to be confused with Mercator, the sixteenth century geographer.

Although folks in ancient times were familiar with fossils and stone implements, they had no clear concept of their true significance, and strange and supernatural powers were often attributed

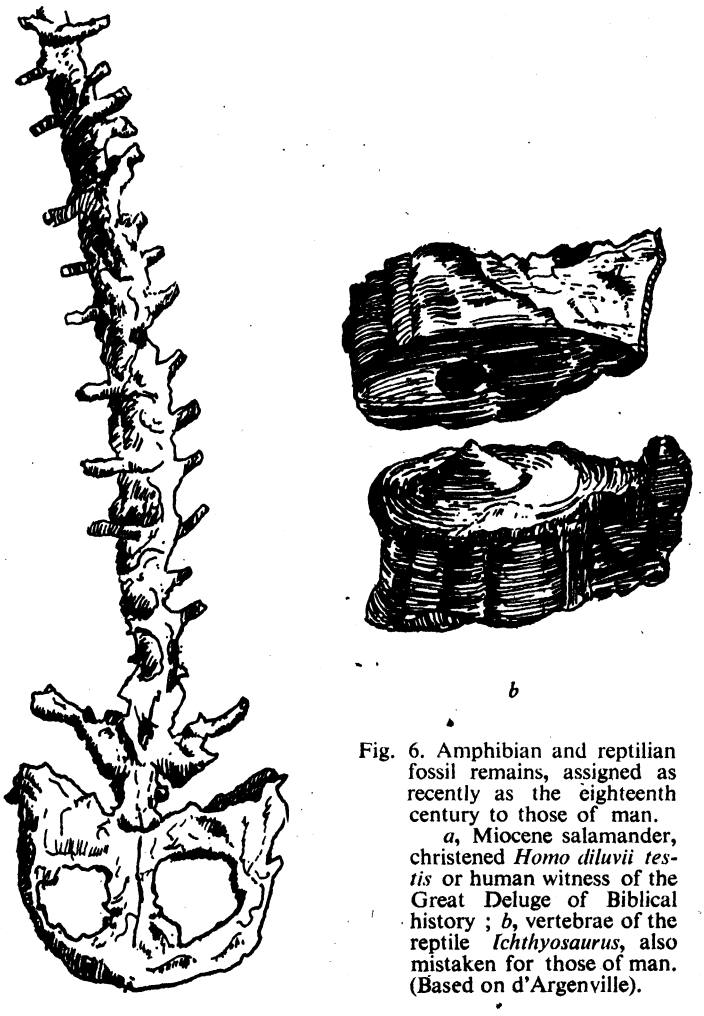


Fig. 6. Amphibian and reptilian fossil remains, assigned as recently as the eighteenth century to those of man. *a*, Miocene salamander, christened *Homo diluvii testis* or human witness of the Great Deluge of Biblical history ; *b*, vertebrae of the reptile *Ichthyosaurus*, also mistaken for those of man. (Based on d'Argenville).

to them. Indeed, such ideas were prevalent as late as the eighteenth and even the nineteenth centuries. It was believed, for example, that life was created periodically in sudden spasms, each time

followed, after a while, by a deluge which buried all or almost all created beings, and that in the case of the last such catastrophe only those who could swim and reach Noah's Ark survived! This is known as the Cataclysmal Theory of Creation. Often when fossils were unearthed, strange interpretations were given concerning them. Thus, we are told that the remains of a Miocene salamander (Fig. 6*a*) found in Europe were actually thought to be those of a man who lived at the time of the Deluge. This 'man' even received the name *Homo diluvii testis*, or a human being who had actually borne witness or testimony to the Deluge ! Likewise, the vertebrae of a fossil reptile, the *Ichthyosaurus* (Fig. 6*b*) that lived long before the human species had even appeared on the face of the earth, were graphically described as "petrified vertebrae from the back of a man."

Indeed, bones of all types of animals were assigned to man. To quote from the American savant, R. S. Lull, "Huge elephantine bones were hung up in churches and other public places for the edification of the faithful, as they were supposed to be relics of the giants mentioned in the Bible. From them Henrion drew up tables showing the dimensions of our antedeluvian forbears. In these Adam was recorded as 123 feet 9 inches, and Eve as 118 feet 9 inches, and 9 lines tall !"—truly formidable products of a forgotten era whose survival would have placed the Food Minister in a serious dilemma today!

It is equally well known that similar ideas continue today in the Indian countryside, and fossil remains of elephants are sometimes regarded as bones of demons ! Similar ideas still prevail in many other lands. But it may be stated in fairness to all, that it was not only the man in the street who laboured under such queer ideas; for we are told that no less an authority than Dr. John Lightfoot, Vice-Chancellor of Cambridge University, announced towards the middle of the seventeenth century that "Heaven and Earth, Centre and Circumference were made in the same instant of time, and clouds full of water, and man was created by the Trinity on the 26th of October, 4004 B.C., at 9 o'clock in the morning."

Even when clearer conceptions of the true nature of fossils became fairly well established, opposition, particularly in regard to the nature of human and anthropoid remains, persisted for a long time. However, it may be said that generally correct

views concerning evolution and descent had become firmly established before the end of the eighteenth century, and the advent of Lyell's *Principles of Geology* (1832) rang the death-knell of the Cataclysmal Theory, while Darwin's epoch-making work, *The Origin of Species* (1859) finally paved the way for the modern ideas on evolutionary principles. There followed many other scientists who by their patience, industry and endeavour accumulated evidence supporting the momentous conclusions of the great masters, and who further wove this evidence into a pattern, a panorama showing the steps by which man arose to man's estate !

THE DEVELOPMENT OF GEOLOGICAL IDEAS IN THE EAST

Views of a Chinese Philosopher of the Twelfth Century

Following the early Greek philosophers, after the lapse of many centuries, a Chinese philosopher, Chu Hi (Tschu Hsi) probed into the secrets of fossils about the years A.D. 1131-1200. For the benefit of the reader, the words of the Chinese philosopher are given below[1] :—

"On high mountains we often see shells of crustaceans and pearl oysters which look as if they have originated from the rock. Such rocks belong to the earth's surface of a previous world-period. Crustaceans and pearl oysters are water dwellers. *That which was deeply below has become above through inversion.* A most careful investigation of the matter would be worth while."

In the above remarks the Chinese philosopher not only gives a correct interpretation of the nature of fossils but also forestalls (see our italics) the theory of the origin of mountain ranges, from the ocean depths.

We have already referred to the ideas of the early Hindus in regard to the major landmarks in organic evolution which were basically correct. They do not appear, however, to have devoted much attention to geological phenomena in general, and apart from a knowledge of minerals, they were probably unaware of the correct nature of fossils and stone-implements. The same presumably applies to the early Arabs and Egyptians.

[1]From a translation by Heinrich Hackmann in *Chinesische Philosophie*, p. 338. Munich, 1927.

This was probably due to the fact that the East was given more to abstract thought while Europe was more inclined towards concrete ideas and things. But it must be confessed that very little information is available to us on this subject and in making the above statement we may have done the people of these lands an injustice, for their knowledge of other sciences, such as astronomy and mathematics, was truly remarkable.

CHAPTER IV

LANDMARKS IN EVOLUTION

Man begins his Career almost as a Worm

WE may now give a more detailed idea of the successive steps in organic evolution that have led up to man. These have already been summarised earlier in Figs. 1 and 2. While we shall here confine ourselves to the major evolutionary landmarks, an account of the various factors, such as inheritance, the influence of environment and more particularly the effect of the struggle for existence between individuals of the same species, which is perhaps most potent of all, will be dealt with in detail in a subsequent chapter entitled "The Vehicle of Evolution."

At the beginning of the record of life about 500 million years ago, man was almost a worm, so to speak. (Some cynics would say that he is not much different from the worm now, in spite of his changed outline). That such were man's ancient relations is known from the indelible impress the worm has left upon the sands of time, in the form of tracks and worm-tubes in some of the oldest known Cambrian and even Pre-Cambrian aqueous rocks (Fig. 7) —an impress more indelible than that left by many a man who considered himself a genius.

Fig. 7. Worm-tubes, over 500 million years old, prove the existence of this form of life in the remote Pre-Cambrian period of the earth's history.

The earlier Pre-Cambrian rocks contain no remains of animals of a higher grade of evolution than the worms in any part of the globe and, therefore, they should be regarded as our first *recognisable* relations. Indeed, at one time they were actually accepted as our *direct* ancestors. It was known that the worms gave rise to the arthropods (which include insects, crabs and scorpion-like forms), but it was further held that the scorpion-like arthropods subsequently gave rise to the fishes which do form a link in our direct line of descent. Morphological and embryological evidence has, however, accumulated to show that the arthropod ancestry of the fishes (and therefore of

ourselves) can no longer be accepted. Our direct ancestry prior to the fishes, is now traced through lancelet-like forms.

Above we have purposely used the word 'recognisable' for though indistinct traces of other, more primitive, organisms have been found, these are types with which the layman is not often familiar. And, in any case, we need not impress upon the reader that, besides having passed through a worm-like stage, he was during a still earlier part of his career a microbe—a minute, creepy, unicellular organism (one of the Protozoa), recognisable only under the microscope with a high-power lens—and that, earlier still, life originated by accident or design, in a manner of which we have no clear conception.

Our probable Lancelet-like Ancestors

Taking the cue from the fact that the most primitive among the modern fishes are devoid of bones, and in place of a true

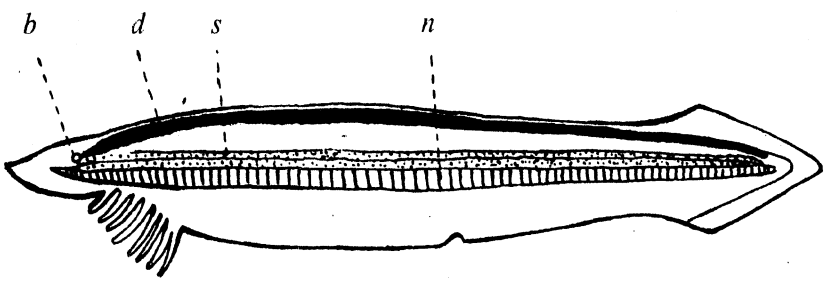


Fig. 8. The modern lancelet, *Amphioxus*, a primitive living chordate, sometimes spoken of as a pre-vertebrate, is a near relative of our very remote ancestors.
Diagrammatic longitudinal section showing *n*, notochord; *s*, nerve cord, corresponding respectively to the vertebral column and spinal cord of the higher vertebrates; *d*, dorsal fin-ray and *b*, brain.

spine possess only an axis surrounded by bony material, it is believed that the forerunners of the fishes and, therefore, of all the vertebrates, are to be looked for in certain boneless ancestors resembling the modern lancelets like *Amphioxus*, classed by zoologists among the chordates. The *Amphioxus* is a small, worm-like sea-creature about two inches in length, and lives near the shore. It is compressed at the sides and tapers towards both extremities, being shaped like a thick spearhead

at one end. The feature which makes *Amphioxus* so important is the presence of a sort of axis, an elastic rod (notochord), foreshadowing the spine of the vertebrates (Fig. 8). The notochord supports a nerve cord which functions like the spinal cord of the higher vertebrates. The presence of the notochord, spinal cord and other characters is thus very suggestive

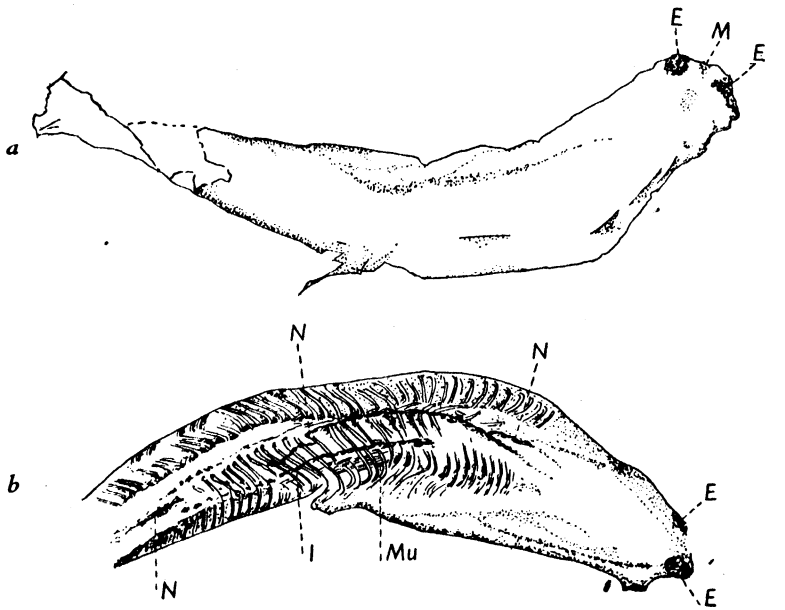


Fig. 9. The most primitive fossil chordate so far known, *Jamoytius kerwoodi*, of about 325 million years ago (Upper Silurian).
a, shows mouth, M; eyes, E; *b*, shows eyes, E; intestine, I; notochord, N; body-muscles, Mu. (After White, simplified).

of the possibility that the higher vertebrates originated from such animals. And, indeed, some zoologists go so far as to include this insignificant worm-like animal *Amphioxus*, with neither limb nor skull, and a mere ganglion (globule of nerve-tissue) for a brain, in the vertebrates !

Till as recently as 1946, no animal remains even remotely resembling *Amphioxus* were known in the fossil state and our knowledge of the probable ancestry of such an important group as the vertebrates rested solely upon living forms. This position was far from satisfactory. It was, therefore, fortunate that as a result of the brilliant work of a British palaeontologist,

White, a form which is apparently closely related to *Amphioxus* and may be even ancestral to it, was brought to light. So perfect is its state of preservation that even the details of the structure of its muscles can be studied. And this despite the fact that it was found in Upper Silurian (Ludlovian) rocks which take us back about 325 million years. This animal, which has received the name *Jamoytius kerwoodi* (Fig. 9), was found by William McPherson in Scotland. It lay unnoticed for over thirty years in the British Museum, for in those times photographic and other technique had not sufficiently advanced to elucidate details of what then appeared to be poorly-preserved specimens.

The form *Jamoytius* was an inhabitant of the muddy waters. It was much larger than *Amphioxus*, attaining a length of 15-18 cm. It was tubular in shape and possessed a flattened head, large, circular eyes, situated anteriorly, and a terminal mouth. The animal, which possessed only a frail internal skeleton without bony material, was furnished with four fin-folds, two at the sides, one on the upper surface and a fourth situated posteriorly, known as the anal-fin. The most important structure, the notochord, as also the impress of the intestine and the body muscles, are clearly seen in one of the fossil specimens.

This interesting fossil, according to White, is "undoubtedly the most primitive of the 'vertebrate' series of which we have knowledge." Such forms come nearest to the most primitive representatives of the fishes and it is therefore believed that the fishes were derived from some forms resembling *Jamoytius*.

There is another very interesting group of animals known as the tunicates[1], to which the so-called 'sea-potatoes' or 'sea-squirts' belong (Fig. 10). These are believed to be not very far removed from the direct line of descent of man. The sea-squirts have a very peculiar history. When young, they look like small tadpoles (Fig. 10 *b*) and at that stage they possess, like the lancelet, a notochord suggestive of the spine, and a rudimentary, tubular nervecord functioning like the spinal cord of the higher vertebrates. Very soon these tadpole-like young of the sea-squirt attach themselves to a rock by means of an adhesive

[1] The tunicates and lancelets are both grouped by zoologists in the chordates because of the presence of the notochord, etc. The tunicates are often hermaphrodite, that is, both sexes are found in the same individual. In the lancelets, the sexes are separate though there is no outward distinction to indicate this.

disc situated in the region of the mouth (Fig. 10*c*) and become permanently fixed, their career of locomotion coming to a sudden and inglorious end. They then begin to grow and, on maturing, look more like potatoes than anything else (Fig. 10*a*). At this stage they lose all trace of the notochord and nervecord. The reader will thus see here a remarkable case of *retrogression* (going backward) where a race has placed its evolutionary vehicle in the reverse gear, so to say. This is a phenomenon to which reference will be made again.

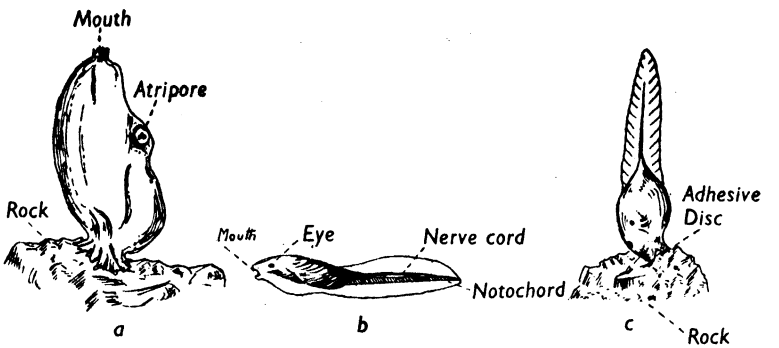


Fig. 10. The 'sea-squirt' or 'sea-potato', one of the tunicates (chordate), at different stages of development.

a, adult 'sea-squirt' fixed to rock; *b* and *c*, young stages resembling tadpoles, which fix themselves to rock by means of an adhesive disc shortly after birth, as in *c*; they then become metamorphosed into a potato-like form with mouth and atripore, as in *a*.

In those tunicates which took the path of the vertebrates (if we accept this view) the axis, instead of being lost as in the sea-quirts, became, on the contrary, more developed and finally gave rise to the spine of the vertebrates, as first found in the true fishes. Such then may have been the remote ancestry of the vertebrates, and if the aforementioned view is correct, we have developed from a relative of the sea-potato !

Uncertain Origin of Vertebrates

In spite of the discovery of *Jamoytius*, we do not really know when, where or how exactly the vertebrates arose. Almost every invertebrate group has been invoked at one time or another as ancestral to them. Apart from the origin of the vertebrates through lancelet-like forms, much still remains unsolved. The

origin of the early chordates themselves is still one of the unfathomed mysteries of evolution, into the inner secrets of which we have not yet been able to enter. At all events, we know that already in the latter part of the Ordovician period that is, in less than 150 million years of the *beginning* of the records of life upon the globe, the highest group of the Animal Kingdom, the vertebrates, had already appeared on the scene, almost in indecent haste !

Running Fresh Water—a Major Incentive in Evolution

The restless ocean teeming with life in its millions was the theatre where the curtain was raised upon the opening scene of the great drama of human evolution, some 500 million years and more ago. But strange as it may seem, there is every reason to believe that the major landmarks in evolution—the rise of the fishes from lancelet-like forms, and of the amphibians from the fishes—were the result of struggle in fast-running fresh water, not in the ocean depths. And this despite the fact that the most primitive living members of these groups (the lancelets and the boneless fishes among the chordates) are mostly marine. Supporters of this theory argue that these are descendants of the original fresh-water inhabitants, and that *they have returned to the sea* on account of competition and other environmental factors. The evidence upon which these views are based is varied, but we cannot deal with it here. It is however worth noting that the earliest fishes are found in Ordovician *fresh water* sediments, while the amphibians were probably derived from certain fresh water fishes in the Devonian—*not* from marine forms.

The First Animals to breathe Atmospheric Air

While the vertebrates began to shape their destiny in the Ordovician, the end of the Silurian witnessed the rise of the first air-breathing animals about 320 million years ago. Indeed so far as our present knowledge goes, *the scorpions of the late Silurian were the first animals to breathe atmospheric air*, and they have persisted with but little change up to the present day. The scorpions, however, belong to the great group of the arthropods, (one of the most ancient among invertebrates) which

originated, in all probability, from the annelid worms. The arthropods beat the vertebrates in the race for the unexplored surfaces of the continents. They learned to breathe dry air through their "tracheæ" long before the vertebrates acquired their lungs. It was, however, not till the Middle Devonian, about 280 million years ago, that the first air-breathing vertebrates, the so-called lung-fishes appeared.

With the dawn of the Carboniferous period, and even earlier, in late Devonian times about 260 million years ago, a great change came over the course of evolution of freshwater vertebrates. Some fishes, forsaking their primaeval aquatic home began gradually to adapt themselves to a land-living habit, and underwent remarkable changes. In fact, they developed true lungs for breathing atmospheric air and gave rise to descendants with limbs suitable for terrestrial locomotion. Of course, these changes were accompanied by other, equally revolutionary, changes in their physical make-up. Thus arose from the fishes the group known as amphibians, some members of which spend a part of their life-history in water, like the tadpole stage of the frog, and are capable, when fully grown, both of terrestrial and aquatic existence. This characteristic gives them their name amphibian, from the Greek, *amphi* = both, *bios* = life, meaning capable of a double mode of life. How this remarkable transformation took place will be explained presently.

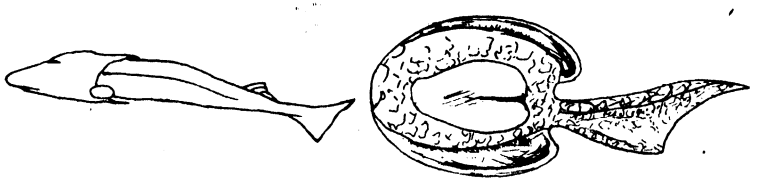
CLAIMANTS AMONG FISHES TO AMPHIBIAN ANCESTRY

The Ostracoderm and Placoderm Fishes

The question may now be asked as to which particular group of fishes gave rise to the Amphibia. Questions of this kind require a great deal of technical detail for a satisfactory answer. We cannot, however, afford to enter into complex technicalities in a work of this nature and, therefore, it is proposed to give only a broad survey of facts.

One group of fishes that is believed to be not far removed from the direct line of the higher vertebrates, is known as the ostracoderms, meaning fishes with bony skin (Fig. 11). These in certain respects resemble the arthropods superficially and the more advanced fishes in others. As their name suggests, the

exterior of the ostracoderms consisted of a bony case composed of plates, but they had no bony internal skeleton; nor did the ostracoderms possess well developed paired fins, while in some cases such fins were altogether absent. These fishes are now all extinct but they reigned supreme from the Upper Ordovician to Upper Devonian times, and *during much of this long interval of over a hundred million years they were the only true vertebrates on the earth.*



a *b*

Fig. 11. Primitive fishes with external bony skeletons known as ostracoderms, which originated in Ordovician times.
a, depressed Silurian form; *b*, *Drepanaspis* from the L. Devonian. The ostracoderms are all jawless. They gave rise to the placoderm fishes from which in turn the amphibians are believed to have arisen.

Were the ostracoderms the earliest among fishes? Evidence in regard to this is not easily forthcoming. It seems improbable, however, that such was the case for it might be reasonably expected that the first fishes were completely devoid of hard parts, as are the modern jawless, boneless, primitive lampreys, but these boneless denizens of the pre-Ordovician waters would not in any case have much chance of preservation. And it would only be a rare chance, like the find of the boneless *Jamoytius kerwoodi*, that would lead to their discovery in the fossil state.

Morphological evidence seems to point to the fact that it was from the ostracoderms that the more advanced fishes, such as the placoderms (meaning plated-skinned), descended, though so far no form has come to light which might be *definitely* regarded as ancestral to the placoderms. However, apart from a detailed comparative study of these groups, the fact that the ostracoderms are on the whole geologically earlier, does seem to indicate (though this cannot be taken as proof) that they gave rise to the placoderms. And it is from these placoderms, more particularly from their subdivision, the arthrodires of the Lower Devonian, that the ancestry of the amphibians is sometimes looked for.

The arthrodires were fresh-water fishes, mainly occurring in the Lower Devonian, and they became extinct towards the close of Devonian times. They have received this name because of their jointed necks. They possessed elements of an internal bony skeleton and jaws which were more frequently cartilaginous, that is, composed of soft material as of the ears, than ossified (bony). Some of these fishes attained large size as, for example, *Dinichthys*, which measured 30 ft. in length. They showed a tendency on the whole towards adaptation from fresh water to marine conditions and from small to large size.

The Crossopterygians and the Dipnoi or Double-breathing Fishes

Another group of fishes from which the higher animals with backbones are likely to have descended are the crossopterygians or fringe-finned fishes. They have already a pair each of shoulder fins and abdominal fins, the elements from which the limbs of land-living animals were to evolve. In some of their early descendants a new breathing apparatus had begun to form. These comprise the dipnoan fishes which possess lungs, as do the land-living animals. These fishes, fossils of which have been found, could breathe atmospheric air freely when the ponds in which they lived dried up. This, as we shall presently see, is an important step towards the evolution of the amphibians. Moreover, they possessed nostrils opening into the mouth, as amongst the advanced vertebrates, and thus could breathe air by means of both gills and lungs, which incidentally gives them their name Dipnoi, or double-breathing animals.

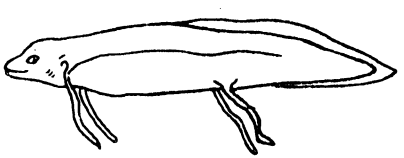


Fig. 12. The living dipnoan, *Protopterus*, from Africa. It burrows itself into soft mud when the marshes in which it lives dry up, this being the first step towards adaptation to life on land. (After Miall).

A living representative of these dipnoan fishes is the African *Protopterus* (Fig. 12), which burrows itself into soft mud when the marshes in which it lives dry up, and thus weathers the dry season till the habitat is replenished by rain. A point of equal interest is that it possesses long, slender fins with a bend in the middle (reminiscent of the limbs of the higher vertebrates)

upon which it sometimes appears to be walking under water. Another interesting dipnoan is the *Lepidosiren*, a lung fish from

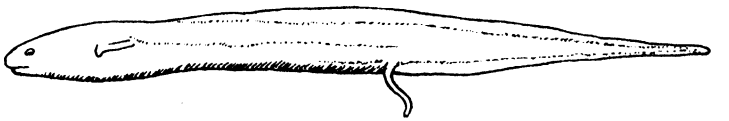


Fig. 13. *Lepidosiren*, a dipnoan from South America. The 'double flexure' in the hind limbs of this fish corresponds to the knee and ankle joints of the higher vertebrates, and represents a stage in the evolution of their limbs. The fore limbs are degenerate. (After Graham Kerr).

South America which also has rather long, slender fins (Fig. 13). These fins are used to support the fish at the bottom of the pond,

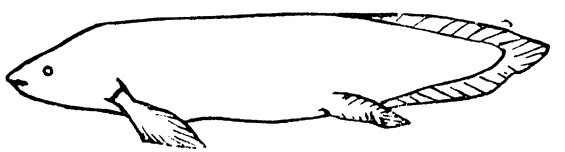


Fig. 14. *Ceratodus*, from Australia. This genus has survived since Triassic times through over 150 million years. (After Graham Kerr).

as if standing upon a pair of legs, like the *Protopterus* just referred to. In some respects a most important form is the dipnoan

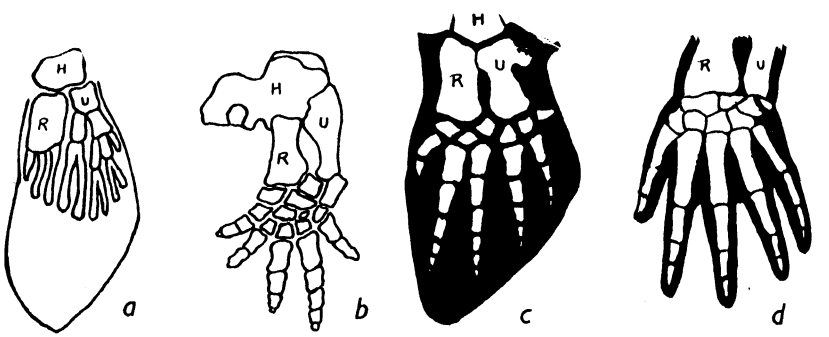


Fig. 15. Illustrates the general lines of evolution of the limbs of vertebrates. *a*, fin-bones of the Upper Devonian fish, *Sauripterus* (Adapted from Gregory); *b*, bony skeleton of right limb of *Eryops*, a Permian land-living amphibian (After Gregory); *c*, skeleton of whale "fin" and *d*, of human hand (After Beadnell). Note the general similarity of bone-patterns in all—fish, amphibian, aquatic mammals and man. H = humerus, R = radius, U = ulna.

Ceratodus (Fig. 14) living today in parts of Tropical Australia. This fish has survived since Triassic times through a span

of over 150 million years. It may thus be correctly described as a 'living fossil.'

It will be observed that by various stages certain fishes had acquired a tendency to develop structures resembling the limbs of the higher vertebrates; the lines along which this was achieved are indicated in Fig. 15. At the same time, they also

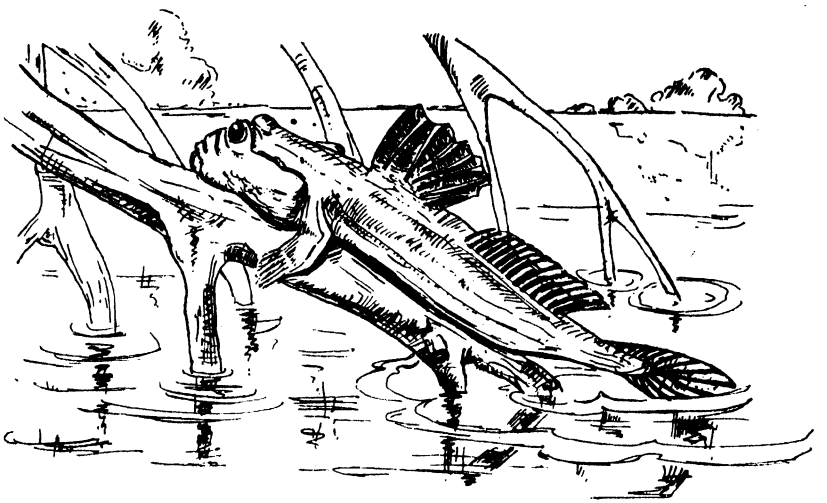


Fig. 16. *Periopthalmus*, a fish living in the rivers of tropical Africa, walks faster than man and climbs trees. It can survive out of water for long periods. This may be considered as a further attempt (see Fig. 12 above) to invade the land-regions, in which the amphibians have succeeded to a great extent. (After Beadnell).

acquired the ability to breathe atmospheric air like the land-living animals. These characters are suggestive of intermediate steps between the fishes and amphibians. Of such forms the extinct *Sauripterus* (with well-differentiated limb-bones) and the living teleostean *Periopthalmus*, which climbs trees (Fig. 16), are good examples. In the same connection we may mention the climbing Perch of the Indian and African waters, which *walks* ashore by means of spines on its fins (Fig. 17). But it must be clearly understood that these and similar forms merely illustrate objectively the probable course of evolution and they do not necessarily constitute the actual missing links themselves. Let us now see

how the fishes ultimately gave rise to the group of amphibians.

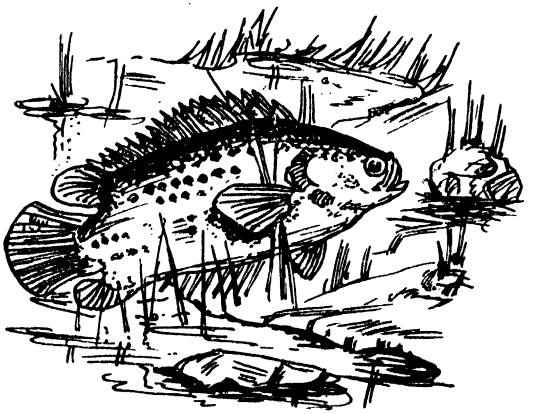


Fig. 17. The Climbing Perch of India and Africa, walks ashore by means of spines on its fins. (After Beadnell).

THE RISE OF AMPHIBIANS FROM THE FISHES IN UPPER DEVONIAN TIMES

Distinctive Characteristics

In shape and form the amphibians look a great deal like the

Fig. 18. Footprint of the oldest known amphibian, *Thinopus antiquus*, from the Upper Devonian rocks of America. This is the earliest known footprint of a vertebrate in geological history.

reptiles, but otherwise they are more akin to the fishes. Like

the latter, they possess a slimy skin and lay a multitude of eggs which are invariably without shells. The small amount of food stored in them makes it obligatory for the young to hatch within a short interval of the eggs being laid. The amphibians are an unprogressive group today, nor have they played a dominant role in any period of the earth's history, such as some other groups have. Their best known living representatives are the frogs, toads and newts.

The earliest amphibian of which there is any record has been named *Thinopus antiquus* (Fig. 18) and comes from the Upper Devonian formation of Pennsylvania (America). But we know this amphibian only from its footprint which, incidentally, records the oldest known vertebrate foot in geological history ! Not only was the amphibian foot the first among those of the vertebrates to pace dry land (so far as our present knowledge goes), but the amphibians were probably the first animals to have a voice.

The Early Amphibians : Evidence of Fish Ancestry

With the exception of *Thinopus*, known from the Devonian rocks, there was till recently no fossil record of an amphibian

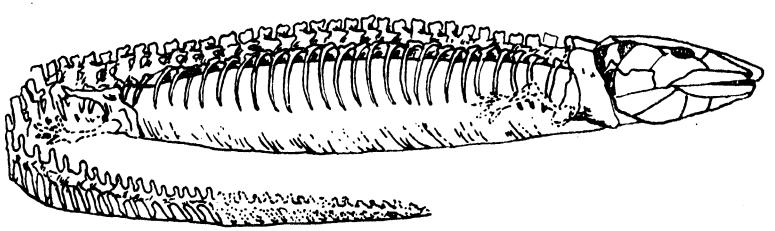


Fig. 19. *Eogyrinus*, one of the early (Lower Carboniferous) fish-like amphibians. Note its very rudimentary limbs which are believed to have evolved from the fins of fishes. Original about 15 ft. in length. (After Gregory, modified from Watson).

from these or earlier formations. Certain remains discovered within the last few years appear, however, to belong to amphibians and are most intriguing. They are nevertheless somewhat problematical, for either their affinities or their age seems uncertain. As Romer puts it, "in one case the find is definitely Devonian but doubtfully amphibian, in the other definitely amphibian but doubtfully Devonian."

One of these finds is *Elpistostege* from the Devonian of Canada. This fossil consists of a well-preserved skull which is intermediate in structure between the (crossopterygian) fishes and the amphibians, bearing a striking impress of both groups. It is only the relative importance of certain characteristics which weighs in favour of its being regarded as an amphibian. Without entering into technical details, it may be stated that the generalised character of the *Elpistostege* skull is seen in its proportions which are intermediate between those of the fishes and the amphibians.

Certain other fossil skulls found in fresh-water beds in Greenland definitely belong to primitive amphibians, probably the earliest known so far. But it is by no means certain whether they are of Upper Devonian or Lower Carboniferous age. The high and narrow skull of the Greenland form, *Ichthyostega*, measures about six inches in length. It was devoid of the operculum which covers the gills in fishes, and the front part of the skull was more amphibian in proportions. However, certain other characteristics seem to indicate that *Ichthyostega* was probably a side branch of the stock from which the later amphibians developed, and not directly ancestral to them.

Another early amphibian of which fossil remains have been found is a form to which the name *Eogyrinus* is given (Fig. 19). It attained a length of as much as 15 feet and possessed a high and elongated skull but only rudimentary fish-like limbs. Other fish-like characteristics of *Eogyrinus* are the presence of spaces in the palate, and certain features which indicate that movement was still possible between the skull and the palate. In the true amphibians and other higher vertebrates the palate is securely joined to the skull and can no longer be moved. Remains of this form were found in rocks of Lower Carboniferous age, which means that it lived about 250 million years ago. *Eogyrinus* and its close allies became extinct in early Permian times.

Although *Eogyrinus* was a primitive amphibian, certain reptilian tendencies are already noticeable, particularly in the structure of the skull, even if not of the vertebrae. It appears to have represented the stock from which many of the later amphibians arose. Many forms have been discovered in geologically younger deposits which recede more and more from their fish ancestry, as they come nearer to us in time. In short, they acquire greater and greater likeness to the true amphibians as we know them today.

If further proof were needed of the relationship between the fishes and amphibians, it is supplied by the fact that the early stages of even the most advanced members of the amphibians show considerable similarity with the adult fishes. For example, the amphibians pass through a fish-like stage—the tadpole—which, like the fish, cannot survive outside its aquatic home. And we might refer to *Branchiosaurus* (Fig. 20) of the Upper

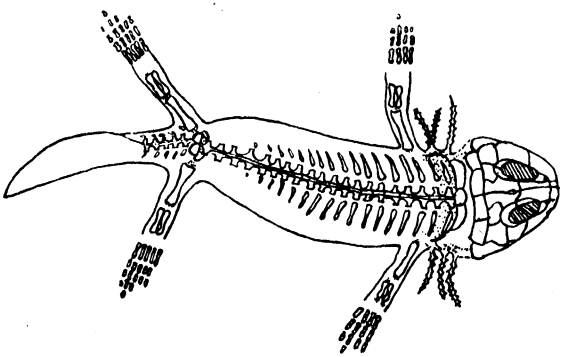


Fig. 20. *Branchiosaurus*, the young stage of a Lower Permian amphibian showing external gills, like the tadpole. It also possessed internal gills. (After Bullman and Whittard).

Carboniferous and Permian times which bore a striking resemblance to a tadpole. In fact, according to Romer, recent evidence shows that *Branchiosaurus* represents only the larval stage of an amphibian, not an adult. Geologically, the fact that there was a period in the earth's history when there were fishes but no amphibians, gives additional support to the fish ancestry of amphibians, keeping in mind, of course, all other evidence of relationship and physical similarity. The aquatic ancestry of the amphibian is further emphasized by the fact that it cannot lay eggs on dry land. If it wants to lay an egg, it has, as a rule, to swim for it, to its ancestral aquatic environment—there is no getting away from that ! At any rate, the eggs are so laid that on hatching, the young, who have feather-like gills, fall direct into water.

Before we leave this interesting subject we may refer to *Miobatrachus* (Fig. 21). This is a small form, about two inches in length, and was found in the Carboniferous rocks of America. The structure of the skull and vertebrae of this rather unique

animal indicates that it is probably an immediate ancestor of the frogs. *Miobatrachus*, however, looks much more like a tadpole than a frog, and might be said to represent in some respects an intermediate stage between a tailed amphibian and the tailless frog.

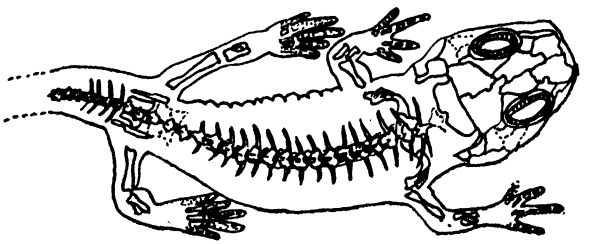


Fig. 21. *Miobatrachus*, a Carboniferous form intermediate between the tadpole and the frog, and ancestral to the frogs. It represents a stage in the evolution of such aquatic forms as were trying to establish themselves on land. Original about two inches long (After Watson).

ARRIVAL OF MAN'S REPTILE-LIKE ANCESTORS

Reptilian Characteristics

Change is the law of nature. Life is a dynamic, not a static phenomenon, and one might well expect to find that the amphibians, after they had established themselves and split into a number of groups, would produce a branch capable of higher evolution. This is what happened, for a most important modification occurred, namely, the gradual adaptation of certain amphibians from the semi-aquatic mode of life, to life exclusively on land. In this manner the reptiles finally appeared in Upper Carboniferous times, about 210 million years ago. This is another of those most wonderful adaptive changes undergone by organic beings—the complete detachment from water and permanent adaptation to a land environment. Along with it, the habit of laying eggs on dry land was made possible by the development of the comparatively hard outer shell as a protective covering, which is absent in the amphibian egg.

Such reptiles as favour an aquatic home have in fact returned to the water after a long period of life on land. This habit is therefore a secondary one, and, in any case, *even the aquatic reptiles lay their eggs on land.* The crocodiles and turtles are good examples. The reptilian egg possesses a

porous shell, and one of its internal membranes, the *allantios*, performs the function of a lung, for by means of it oxygen is absorbed and assimilated by the growing young. In the amphibians, it will be remembered, there is no outer shell-cover, and in contrast to the reptilian egg which contains a large amount of stored food-material (in the form of yolk and albumen), the amphibian egg has very little of it. The reptilian offspring is, therefore, well developed at birth and practically adjusted to its permanent environment. The reptiles can be further distinguished by their better-developed brains, and, externally, by their skin, which is not slimy as in the amphibians.

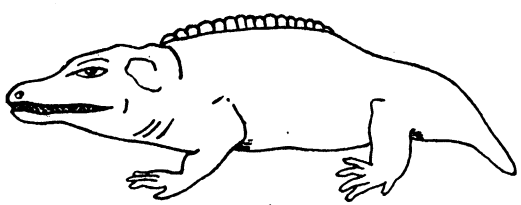


Fig. 22. *Cacops*, a Lower Permian amphibian from America and one of the earliest vertebrates to live on land. (After Abel).

Among amphibians it was customary to distinguish one group known as the Stegocephalia (meaning solid-headed) which originated in Upper Devonian times. The greatest importance was attached to this group, for it was believed to have given rise to the next great Class of higher vertebrates, the reptiles, becoming itself extinct at the close of Triassic times. It was their solid-headed character, indicating that the skull-roof was completely covered by bone save for certain openings for the eyes and nostrils, which gave the Stegocephalia the prerogative of reptilian ancestry, because some of the more primitive members of the reptiles possessed similar skulls. As an example we may mention *Cacops* (Fig. 22), one of the earliest of the Permo-Carboniferous land vertebrates which possessed a skull with such characteristics. Recent work has, however, shown that the division Stegocephalia is a rather artificial jumble of species, for it relates more to amphibians of a certain geological age than to inherent characteristics of any one group.

How then did the true reptiles originate and what were their immediate forerunners? Let us enquire.

Was Seymouria an Amphibian or a Reptile ?

One of the most interesting forms which might give a clue to the ancestry of the reptiles was *Seymouria* of the Lower Permian (Fig. 23). It stood at the frontier-post between the amphibia and the reptiles. A little under two feet in length, it ideally combined the structures of both groups, so much so that different authorities have from time to time classified it with one or the other group. Its skull resembled that of the amphibians

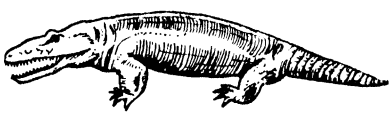


Fig. 23. Restoration of *Seymouria*, a Lower Permian reptile (from America) which resembled the amphibians in many respects. (After Williston).

in that the intertemporal bone was present, while the femur or thigh bone possessed certain characteristics of primitive reptiles. From the foregoing description it appears that in *Seymouria* we are hot upon the track of the progenitors of the true reptiles.

While *Seymouria* was transitional between the amphibians and reptiles, a number of other extinct forms are known which, even if they were primitive types, were nevertheless true reptiles. One of the most primitive of these was *Limnoscelis* from the Lower Permian of America. It was a carnivorous creature of medium size, attaining a length of approximately 5 feet. While the amphibians possess a somewhat flattened skull, even this primitive reptile had a relatively elongated and high one. Furthermore, the number of bones in the *Limnoscelis* skull was less than in the amphibians and this tendency (reduction in number of skull bones), continued in the more advanced reptiles and later on in the mammals. It may also be mentioned that some of the early reptiles possessed teeth in the palate or roof of the mouth. This feature is characteristic of the fishes but is sometimes found in the amphibians, which sheds much light upon the ancestry of these groups. It is also interesting to record that the vertebrae of *Seymouria* and *Limnoscelis* are similar, which shows that the latter which is morphologically more advanced, might have arisen from forms like *Seymouria*.

Our Mammal-like Reptilian Ancestors

As we march forward into time we see a diverse stock of reptiles developing from their Upper Carboniferous and Permian ancestors, a stock as varied in shape as it was adapted to diverse types of environment. One of these early reptile groups comprises the theriodonts or cynodonts which were confined to South Africa. This group is peculiar in that certain of its members began to develop after mammalian patterns, ultimately giving rise to the mammals themselves. The theriodont reptiles thus bear almost the same relation to the mammals, which Class they foreshadow, as the crossopterygian and dipnoan fishes do to the amphibians, whose origin they herald.

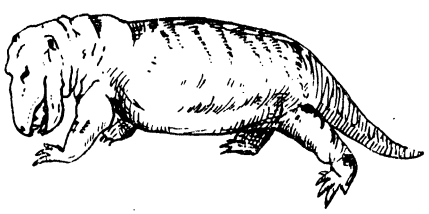


Fig. 24. Restoration of the Triassic reptile *Cynognathus*. It possessed a pelvis resembling that of the mammals. In this and some other respects this form is intermediate between the mammals and the reptiles. (After Gregory).

A reptile which bore particular resemblance to the mammals was *Cynognathus* (Fig. 24). The resemblance is most marked in respect of the hip bone or pelvis, which was like that of the mammals. It must be remembered that, except for the egg-laying mammals, the monotremes (see p. 65), one fundamental difference between a reptile and a mammal is that the latter gives birth to living offspring, not an egg, and therefore the hip bone or pelvis had to become modified so as to support the unborn offspring in its mother's womb and to allow it to pass through in the act of birth. But while a pelvis suggestive of the mammalian type is found in *Cynognathus*, we do not wish to imply that the mammals arose from this particular animal, though we would not be far wrong in asserting that they arose from some form that had many characteristics in common with *Cynognathus*. The mammalian strain in *Cynognathus* was equally noticeable in its limbs and well-differentiated teeth. The last characteristic is most important because typically the reptilian teeth are not differentiated into molars, pre-molars, etc.,

but are, on the contrary, fairly uniform in pattern. Differentiation of teeth took place only in those reptiles which were making an attempt to ascend to the status of mammals.

An equally interesting member of the theriodont reptiles is the South African genus *Nythosaurus*, which had a lower jaw like that of the reptiles, composed of several bones, instead of a single bone, as in the mammals, though its teeth were differentiated, at any rate functionally, into 'molars', 'canines' and 'incisors', somewhat after the mammalian pattern, as may be seen from Fig. 25.

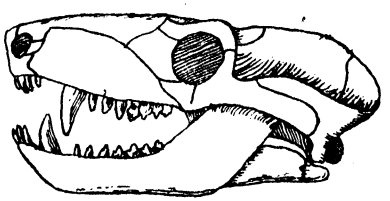


Fig. 25. Skull of *Nythosaurus*, a cynodont reptile. (After Broom, details omitted).

Two early forms that may be regarded as travelling faster than many other forms towards the mammalian road, lived during the Upper Triassic period in America. They are known only from their jaw-bones and teeth and have been named *Microconodon* (Fig. 26) and *Dromatherium*. Elsewhere in this book attention is drawn to the importance of teeth in determining relationships and especially to the presence of certain tubercles or cusps on the upper surface of the molar

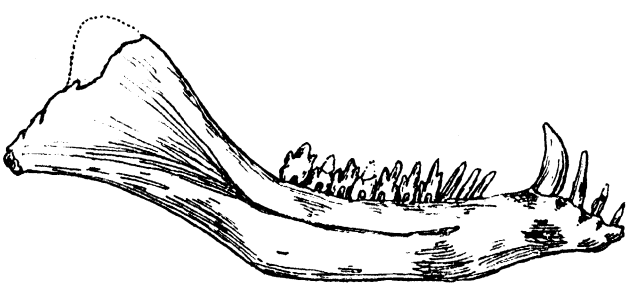


Fig. 26. Left mandible (lower jaw-bone) of the reptile *Microconodon*, viewed from inner side. Its dentition is differentiated as in the early mammals. The molars possess a *protocone*, *paracone* and *metacone*, but the jaw-bone is composed of more than one element, as in reptiles. (After Wilder).

teeth of the mammals. On account of the presence of three to five cusps in *Microconodon* and *Dromatherium*, combined with the fact that the jaw-bone was believed to consist of one single element

(not seven different bones which characterise the reptiles) these genera were assigned to the mammals. However, it has recently been shown that the lower jaw-bone consists of different elements and not one single bone, which proves that both these genera belong to the reptiles and not to mammals. *Microconodon* and *Dromatherium* may thus be considered as undifferentiated or generalised reptile-like forms that were earnestly aspiring towards mammalian status.

Primitive, not Advanced Members of an Animal Group Give Rise to Other Groups

Even though the fact is fairly apparent from the foregoing paragraphs, we might stress that it is not the most advanced member of a group which gives rise to the next succeeding group. It was, for example, not the most highly evolved amphibian that gave rise to the reptiles, not the most highly evolved reptile that gave rise to the mammals, nor the most advanced Primate (as we shall see in due course) from which man originated. This distinction invariably went to the simpler, the less evolved and more generalised types which adapted themselves easily to new environments. For it is at that stage that an animal group is more pliable, more susceptible to changes of climate or other physical impacts, and even to inherent evolutionary trends, than when it has become specialised in a particular direction. Indeed this is evident from everyday life. A man past middle age when his habits are set, hates to be aroused at 5 o'clock in the morning, when he normally wakes up at 8. And however much his spouse may coax or threaten him, she rarely succeeds in preventing him reading the newspaper when she would have him discuss her domestic problems; or to persuade him to postpone the fixture at golf, in preference to— well, anything. Thus change at that advanced stage becomes almost an impossibility. Similarly an advanced (highly evolved) reptile could not change into anything but a still more advanced reptile—and certainly never into a mammal !

It is equally noteworthy that the more primitive the organism the greater is its capacity to survive accidents of life and even to regenerate parts of its body. Thus if you sever a man's head, he will undoubtedly feel most uncomfortable, but will certainly never be able to regenerate another, while if the primitive fresh-water

creature *Hydra* is subjected to the same process, it readily produces a new head, perhaps one wiser than the last. And the process can be repeated with impunity. In fact, even if you divide the *Hydra* into several pieces, each becomes an independent individual, complete in all respects. To take another instance, you will rarely see a lobster with damaged legs for the simple reason that if one of them gets broken, another grows to take its place. But such is certainly not the case with the vast majority of the higher animals. Some examples, however, exist. The most highly evolved animals to show this power of regeneration are the amphibia, in which lost legs are often replaced. Among the reptiles, the lizards, although they can no longer regenerate a complicated organ like a leg, but can at least grow another tail, like our common house-lizard.

Thus, on the whole, pliability and capacity to change and even to regenerate, characterises the more primitive and generalised groups among animals, which are well poised for evolutionary changes at the slightest pretext, and readily respond to external stimuli and inherent trends.

In the end we may emphasize that, although there is diversity of pattern in evolution, there is, nevertheless, definite continuity in the processes involved, however dynamic they may be. Although we may not, from superficial examination, see much resemblance between a segmented worm and an arthropod, between certain fishes and *Seymouria*, or between certain generalised reptiles and the primitive mammals, nevertheless a definite and connected line of relationship runs through them. It is, for example, remarkable that if you examine the skull of any fish, amphibian, reptile or mammal, you will find that there is a progressive reduction in the number of bones in their skulls. Thus, there are fewer bones in the skull of an amphibian than in that of a fish, there are fewer bones in a reptilian skull than in an amphibian skull and, finally, the mammalian skull has still fewer bones than the skull of a reptile. This gives us an indication of the direction in which the evolution of the skull has progressed, and of the continuity of evolutionary processes. And the same is true of many other characteristics among various classes of animals.

It is outside our scope to give details of animal groups which are not directly related to the ancestral lineage of man, but it is

worthy of note that the reptiles were one of the most successful groups during the Secondary era, and peopled the globe with a diversity of type and form that is truly baffling. Among them were the colossal dinosaurs, like *Diplodocus*, attaining a length of nearly 90 feet, and *Tyrannosaurus* over 45 feet long and almost three times as high as the tallest man alive.

THE MAMMALS AND THEIR RISE FROM THE REPTILES

The march of evolution is an unceasing one. The modification of certain amphibians into reptiles occurred almost before the former could, so to speak, recognise themselves as amphibians after their origin from the fishes. Some of the reptiles fared no better for they in turn gave rise, by becoming warm-blooded, to mammals that breast-feed their young and produce ready-made, squeaking offspring, instead of letting them emerge from a commonplace egg, like a commonplace reptile. One of the exceptions to this rule is the duck-billed *Platypus* of Australia. It is the most primitive mammal in existence and still persists in laying eggs ! For this reason it has been placed, along with another genus, in a separate group called the monotremes.

Who were the immediate ancestors of the mammals? When and where did they arise ? What has been the course of their history ? These are some of the questions that present themselves in any consideration of mammalian evolution. We shall accordingly proceed to deal with certain aspects of these problems.

Subdivisions and Characteristics of Mammals

The mammals (Latin, *mamma* = breast) constitute that Class to which belong many of the higher vertebrates with which we are familiar, including man. In view of this last prerogative let us broadly review their characteristics and geological history so that we can gain a clearer concept of the place of man in the scheme of vertebrate evolution.

The modern mammals are classified in progressive order, as follows :—

MONOTREMES : These are primitive types and *include the only two living egg-laying mammals*, namely, the Duck-bill *Ornithorhynchus* and the spiny ant-eaters *Echidna*, of Australia. They possess

primitive milk-glands and hair; their lower jaw-bones are composed of single elements, and they do not possess teeth at maturity. They also have some reptilian characteristics.

MARSUPIALS : Their young are always immature at birth; they possess a *marsupium* or pouch, whence their name; they include the kangaroos and allied forms.

PLACENTALS : Their young remain within the mother's womb for a longer period and are nurtured there by the mother's blood-stream through the *placenta*, which gives them their name; they are almost fully developed at birth, and include all the more familiar mammals and man.

With the exception of the egg-laying monotremes, the most characteristic feature of the mammals is that all of them give birth to live offspring. After birth, the young receive nourishment through the milk-glands situated within the mammae or breasts. The mammals are all warm-blooded animals (see p. 68) and are generally covered with hair which helps in maintaining body temperature. Another important feature, to which attention has been drawn already, is that each mandible is composed of a single element, not a number of bones as in the reptiles.

The brain is large and the higher centres are well developed. On this account, there is a corresponding increase in intelligence and perception, which gives the mammals a great advantage over the other animals and which has contributed to their phenomenal success. Their heart is divided into four chambers and the pure and impure blood-streams have entirely separate circulations.

Typically they possess 44 teeth, though in man there are only 32. The teeth are well differentiated into incisors, canines, pre-molars and molars. The molars, however, develop only after the so-called 'milk-teeth' of the first set have fallen. In the rodents, the teeth which are rootless, even continue to grow in order to keep pace with constant wear. The mammalian teeth are, therefore, quite different from those of the modern

reptiles which show hardly any differentiation and which are constantly being replaced by new ones.

The mammals have adapted themselves to different modes of life—aquatic (whales), volant or flying types (bats), arboreal (monkeys, etc.) and cursorial or capable of fast movement on the ground (horses, etc.). Man, though not particularly adapted to any of these modes of life in the sense that other animals are, can practise all these; and he even flies, though with artificial wings!

The Marsupials

The distinctive characteristic of the marsupials is the *marsupium* or pouch situated upon the belly. They are mostly quaint-looking animals of which a familiar example is the kangaroo. The young of this animal are barely the length of a human finger at birth and so helpless that the mother has to help the offspring with her lips into her pouch[1], where they feed from teats situated within. In short, the young are as if prematurely born and are thus unlike those of the higher, placental, mammals.

The marsupials, furthermore, possess a larger number of teeth than the placental mammals, which shows that they are more primitive. In this respect they come nearer the reptiles, who also possess a larger number of teeth than the mammals.

The earliest representatives of these animals are found in the late Cretaceous rocks. Their geological and present-day distribution is unique, especially in relation to the placental mammals. At the commencement of the Eocene, the South American continent was separated from the northern lands. At that time there were present on this continent some carnivorous marsupials and a few placental mammals but practically no carnivores among the latter. Thus the marsupials flourished more or less undisturbed. In the Australian continent, which was separated from the Asian mainland towards the end of the Cretaceous, the position was even more favourable to marsupial development, for

[1]There is a widespread belief among laymen that the offspring of the kangaroo is born directly *into* the pouch. The extreme helplessness of the young is apparently responsible for this belief. However, apart from the physical impossibility involved, we have it from the kangaroo itself that such an idea is unworthy of this great Australian.

scarcely any carnivorous mammals were present so that the marsupials reigned supreme without competition or fear of extermination. It should, however, be noted that the modern Australian marsupials did not appear till as late as the Pleistocene, though this assumption might be due to deficient geological record.

It is interesting to record that with the exception of the American Opossum, the present-day marsupials are confined to Australia. Since there are practically no placental mammals in Australia (except rats and rabbits and some others brought by man) it is believed that that continent was completely separated from the Asian mainland (in late Cretaceous times) before the placental mammals had a chance to destroy the marsupials. It is equally noteworthy that in those regions where the placental mammals exist (all the familiar mammals, we may repeat, belong to this Class), no marsupials, or hardly any, occur. The marsupial and placental mammals are thus mutually exclusive.

It is scarcely possible or even necessary to deal with the other mammalian types in more detail. And we have to be satisfied with the foregoing brief account which gives an adequate idea, we hope, of the lines along which the mammals began to branch off from their reptile-like ancestors.

Our Ancestors acquire Warm Blood

It is perhaps not commonly known that the mammals are warm-blooded animals while the reptiles are cold-blooded. This transformation took place simultaneously with the modification of the reptiles into mammals at least as early as the Upper Triassic period of the Mesozoic era, 160 million years ago, and possibly even earlier in Permian times.

The change from the cold blood of the reptiles to the warm blood of the mammals is one of the greatest landmarks of evolution. This transformation, some believe, was due to the onset of aridity as an indirect result of earth movements, followed by glacial conditions in the Permian, which made it obligatory upon the mammals to retain a constant high body-temperature irrespective of the temperature of their surroundings. Thus was developed that fine automatic mechanism in the mammals which enables them to retain a favourable temperature under all conditions. The origin of the mammals may, therefore, have been due to these

climatic changes between two extremes, aridity followed by glaciation. Such transformation (cold to warm blood) would obviously be of great advantage to a race. A reptile placed in a cold environment would perish, while a mammal, being able to maintain constant high temperature, would have a far better chance of survival. Hence the rapid rise and phenomenal success of the mammals.

We might emphasize that warm blood was probably not acquired suddenly but by gradual stages. This may be surmised from the fact that all groups of mammals do not possess a uniform high temperature but there are some, like the present-day monotremes, whose body temperature is no more than 30° Centigrade (=86° Fahrenheit) while there are other mammals whose normal temperature is higher than 30° Centigrade though less than that of the placental mammals, which may be as high as 40° Centigrade (=104° Fahrenheit). In human beings the normal body temperature is 98.4°, on the Fahrenheit scale.

Zeuner has suggested an interesting connection between the structure of the teeth and warm-bloodedness. It is obvious that the maintenance of constant high body-temperature requires a supply of calories which comes from the food. Since mammals have teeth which enable them to masticate what they eat, they are able to obtain from a given quantity of food, the extra nourishment (and therefore the extra energy) required to maintain a warm blood-stream.

It may be of interest to note in passing that the birds are the only other Class which possesses warm blood, beside the mammals. The Class of birds, however, originated (from the reptiles) much later than the mammals, in fact, in the Jurassic times of the Mesozoic era. This discounts the theory of the origin of warm blood as the immediate result of a cold climate following in the wake of arid conditions, for a vast interval of time intervenes between the Upper Trias, when the first mammals appeared, and the Jurassic, when the first birds came on the scene. While actual fossil remains of birds are not known earlier than the Jurassic, it is not inconceivable, however, that there may be a gap in our record of discovery, and further investigation might prove that, after all, they originated earlier.

Geological History of the Mammals

Although the mammals arose in Upper Triassic times, our

knowledge concerning these is yet imperfect. Indeed it is one of the puzzles of mammalian evolution that not till the late Cretaceous or early Tertiary do we find anything but fragmentary remains of this Class.

Among the early forms, four mammalian Orders are known in the Jurassic, namely, the Triconodonta, the Symmetrodonta, the Pantotheria or Tritubercula and the Multituberculata. Except the Multituberculata which survived into the Tertiary, these Orders all became extinct towards the close of the Jurassic.

The Triconodonta were characterised by molars with three conical cusps—a type which might have originated from one resembling the *Cynognathus* molars to which we have already referred. The Symmetrodonta, as the name implies, possessed molars with three cusps arranged symmetrically in triangular form. The Multituberculata are characterised by several tubercles or cusps in their molars, serially arranged, which incidentally accounts for their name. They were of comparatively large size and, of the Jurassic mammalian Orders, they alone persisted into the Eocene.

The Pantotheria or Tritubercula are of the greatest interest to us because *they are believed to have given rise to* all the higher (placental) mammals and possibly also to the marsupials. The roots of human origins thus also lie in them. Their molars possess three tubercles or cusps, with an additional *talon* or 'heel'. This little structure has an important bearing upon the evolution of the typical mammalian molars. According to supporters of this view (as against the Tritubercular theory of the origin of mammalian molars, which no longer holds the field) the heel or *talon* contributed towards the development of the five-cusped condition characteristic of the typical mammalian molars.

It is of interest to record that the Insectivores or insect-eaters, which constitute the most primitive living representatives of the modern placental mammals, are probably closely related to the Pantotheria whose origin they herald.

Primitive Mammals

We have referred above to two generalised types from the Trias, *Microconodon* and *Dromatherium*, which were at one time

regarded as mammals, but which are now classified with the reptiles. From this the reader will obtain some idea of the difficulties which one encounters in dealing with such *generalised* types which combine in their anatomy the characteristics of more than one Class. When we come to the Jurassic we are on surer ground. Here we meet with such forms as *Amphilestes* (one of the Triconodonta) in which the jaw-bone was composed of a single element though the molars resembled, in some measure, those of the reptile *Cynognathus*. It is believed that molars such as those of *Cynognathus* could have given rise to the type of molars found in the primitive mammal, *Amphilestes*. A more advanced type is the Upper Jurassic *Priaconodon*, in which the individual cones are of more uniform size and, therefore, approach still later forms (Fig. 27*a*).

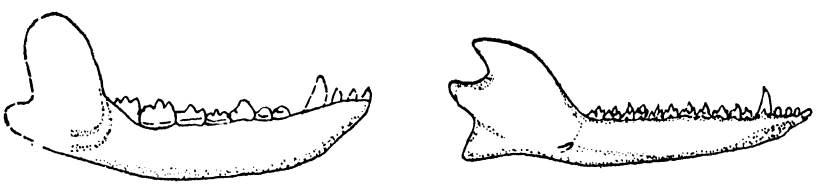


Fig. 27. Jaw-bones of early mammals.
a, *Priaconodon* (Upper Jurassic) and *b*, *Amphitherium*, (Middle Jurassic), viewed from inner side ; both from America. Note the differentiation of molars. (After Simpson).

Of the Pantotheres, from which all the higher mammals are believed to have arisen, we may mention *Amphitherium* from the Middle Jurassic. The molars of *Amphitherium* (Fig. 27*b*). have three cusps, disposed in the form of a symmetrical triangle, as also the *talon* referred to above.

The Mammals almost disappear for 69,000,000 years

The close of the Jurassic witnessed one of the strangest things that ever happened to an animal group. With a few rare exceptions, such as *Plagiaulax*, remains of which are recorded from the Upper Jurassic rocks, the mammals seem to have disappeared almost completely from the face of the earth! Even allowing for the fact that the mammals were not yet a flourishing group during the Trias and the Jurassic, and that all of them were of small size, being never bigger than a rat or a small rabbit, their scarcity

during the entire Cretaceous period, spanning a time-interval of 69 million years is indeed difficult to explain. What is equally baffling is that when finally we do meet the mammals again in in the early Eocene, following their black-out in the Cretaceous, they are still of primitive design, as if the Almighty had almost stopped the Clock of Evolution at the end of the Triassic period and, giving it a shake, started it at a more rapid pace in the Eocene, to resume its normal ticking. Thus for a period of 100 million years and more (spanning the whole of the Jurassic and Cretaceous periods and a part of the Trias) the wheel of mammalian evolution turned but slowly! What could possibly have been the cause of this event ?

We have mentioned earlier that the climate of different parts of the globe has undergone vast changes, and regions upon which the tropical sun once blazed now lie covered by, not hundreds, but thousands of feet of ice. Such is the case with the Arctic regions that were once covered by a tropical vegetation of colossal ferns, rivalling trees in size, during the Cretaceous, and now lie buried deep beneath vast blankets of ice. It is presumed that it was in this region alone that the Cretaceous mammals flourished and thus it is that their remains have not been unearthed so far. It might, therefore, be a case not so much of actual disappearance or eclipse as lack of discovery, on account of the evidence having become masked or destroyed by the hand of Nature. And, one day, we may expect to find a rich treasure of mammalian bones beneath the ice-fields, giving us the clue to the missing links among the mammals, bridging the gulf between the Jurassic forms and their Tertiary descendants. An alternative explanation of this may be that the Cretaceous was a period of great marine transgressions, which means that vast land areas were submerged by the invading seas, so that remains of the land-mammals could not be numerous. In support of this may be mentioned the fact that very few land-deposits of Cretaceous age are known.

A third possibility was pointed out by Zeuner who studied the time-rates at which evolutionary changes occur. He found that whenever a new branch evolves on the tree of life, progress is at first slow. This initial "lag phase" lasts sometimes many millions of years. Thereafter the group blossoms out suddenly (*Explosive Evolution*, see p. 75) and many variants of the

group-type appear in succession. Among these three possibilities, the last may be the sole cause of these phenomena, but quite likely all three have contributed.

The Clock of Evolution resumes its Ticking.

After the "Silence of the Cretaceous", there appeared early in the Eocene, generalised mammals classed as the Creodonta, from which (or from closely allied forms) arose various Orders of the carnivorous or flesh-eating mammals.

The commencement of the Eocene also marks the first arrival of the hoofed mammals (perissodactyls) like the horse, as well as of the elephants (proboscidians). But of far greater import, and certainly of far greater interest to us, was the appearance during the early Eocene and even earlier, in the Palaeocene[1], of the Order Primates, which includes the most unique product of nature—Man.

The commencement of the Eocene therefore heralds the influx of many different types of mammals that gradually ousted the reptiles who had held sway throughout the Mesozoic period, spanning 124 million years. It is not within the scope of this work to follow the fortunes of all these mammals, even though they have fascinating stories to tell. We shall, in due course, record the history of one group only, the Primates, for it is this group to which man and the apes belong, and with which we are primarily concerned.

To end, we thus witness on the Tertiary scene a race between the reptiles bravely struggling for supremacy, and the mammals forging ahead, surely, steadily, unerringly—a race well run, and well won !

[1]This is a subdivision of geological time (not in common use) which is interpolated at the end of the Cretaceous and forms the basal member of the Tertiary.

CHAPTER V

THE VEHICLE OF EVOLUTION

THE BASIS OF ORGANIC CHANGE

AT this point it is appropriate to consider the processes which initiate or control evolution—factors by the play of which new forms of life—animal or plant—appear. A discussion of these processes will enable us to understand more clearly the further evolution of the mammals and the rise of the Order Primates.

There is an important aspect of evolution to which we must draw the reader's attention at the very outset. To the layman and the student not fully conversant with the principles that govern change in organic life, Evolution invariably implies Progress, perhaps one grand triumph after another, as though reaching the climax of a musical symphony! This is, however, far from being the case, for Evolution comprises both Progress and Retrogression, success and failure, survival and extinction. In the evolutionary race the 'also ran' evolves as much as the one that leads and, as on the race-course, only a few succeed while several merely finish the course—in good time, or not at all. And sometimes a horse (to be sure the one that you have laid your wager on) starts running back towards the starting post. So it often is with evolution, as we shall presently explain.

This brings us to another important point. Evolution is not to be regarded as invariably following a definite direction, changing organs by successive steps, each followed by another of the same kind. In other words, progress is not like climbing a ladder by regular and graded steps, but often evolution follows a divergent pattern, like the forking branches of a tree, developing in many directions according to the effect of environment. This is described as *Adaptive Radiation*, which further implies that when a new group arises, it produces many divergent forms that become established according to their abilities to adapt themselves to their surroundings. Palaeontology is replete with examples of this kind, one of which, nammely, the rise of several and varied Orders of the mammals in the Jurassic has been already referred to. What if nearly all of them met their doom about the

close of that period, for this is only a just penalty of existence. When evolutionary episodes (like the simultaneous or almost simultaneous origin of varied Classes, Orders, Families, Genera or Species) take place in a comparatively short span of time (geologically speaking), the phenomenon is termed *Explosive Evolution*. An example of this among the vertebrates is the rise of the different Classes of Fishes in Siluro-Devonian times. Among invertebrates, a good example is that of the Jurassic Terebratulidae of which twenty-four genera are known, compared to four in the Trias, ten in the Cretaceous and six in the Tertiary (i.e., only twenty genera in all the three periods put together, as against twenty-four in the Jurassic alone).

Evolution by graded steps is called *Orthogenesis*. One of the finest examples of this is the evolution of the horse, an account of which is deferred to a later stage, as we propose to deal with the subject in detail.

Struggle for Existence ; Natural Selection ; Survival of the Fittest

The questions now arise : What are the fundamental causes which initiate these evolutionary changes? And why do some modifications have so much cumulative effect that in course of time a species begins to look quite different from its original and then constitutes a new species ? Although these processes give rise to such vital results, almost changing the shape of creation, their operation is quite simple. Let us explain these phenomena by two examples, one the result of human agency and the other where Nature is her own architect.

Now we know that all intelligent farmers try to improve the breed of their stock, flowering plants and fruit. They select certain individuals which show specific favourable characteristics and then interbreed them. Those modifications or 'mutations' which result from 'germ cells' are inherited by each successive offspring and thus, after several crossings, a completely new variety may be produced by *Artificial Selection*. Thus luscious varieties of fruit have been produced. The numerous varieties of dogs are similarly believed to have been derived from continuous cross-breeding of some wild form, probably the wolf. Some geneticists have even succeeded in creating monsters in this manner.

The other example that we select is from nature and one which had a profound influence upon life on the globe, namely, the adaptation of certain aquatic animals to life on land. This phenomenon is well exemplified in the frog and its tadpole and was one of the greatest revolutions in evolution, even though the progress was gradual. We shall explain briefly how this change took place more than once, is taking place even at the present day, and must continue to take place so long as the physical nature of life remains unchanged.

If you have lived by the sea-shore, you may have noticed that when the tide recedes, a number of fish and other sea-animals may be left struggling on the mud flats. A similar fate awaits the fishes in the village pond each summer when the water begins to dry up. And in the past, other fishes had to struggle likewise. They lived in the slowly drying pools as long as they could, but as the water began to dwindle, they began to burrow into the soft mud, in a sheer effort to survive. This was a matter of life and death for them—a veritable *Struggle for Existence.* Many must have succumbed in this struggle, but some that became more resistant by producing favourable variations suited to the changed environment, lived on. Nature has her own process of weeding out the unfit and retaining the fittest—a process which Darwin called *Natural Selection.* By having to struggle repeatedly with the changing environment, some of the fishes that could at first live only in water, gradually learned how to live in wet mud and to breathe atmospheric air by developing a suitable breathing apparatus, such as lungs. This proved the doctrine of *Survival of the Fittest.* By further repetition of this process some of these fishes were ultimately enabled to survive long periods of desiccation, and thus finally some of their descendants became used to living on land for at least part of the year. In fact they began the conquest of a new type of *lebensraum* —terra firma. They thus gave rise to the amphibians or animals which spend one part of their life in water and the other mainly on land.

Evolution of course implies the impact and impress of many factors. Of these, competition between individuals of one and the same species, for instance over food supply, is important. It is obvious that scarcity of food also results in a keen *Struggle for Existence* and, as a consequence, structural changes,

Responsive Adaptations, are produced to meet the changed conditions of life. It may be explained that responsive adaptations are changes appearing in response to altered environment. Thus, only those individuals survive which are best fitted to the changed surrounding conditions in competition with each other. This again illustrates Darwin's famous law of *Natural Selection* and proves his well known dictum of the *Survival of the Fittest*. This struggle for survival in a changed environment carried on by means of adaptation is believed to be the main factor in evolution. It results in the appearance of new species.

Darwin and Wallace were inspired by the Economist Malthus

How did these ideas come to Darwin—ideas that are as simple as they are far-reaching and magnificent in their scope?

Strangely enough, the conceptions embodied in the aforementioned principles—*Struggle for Existence*, *Natural Selection* and the *Survival of the Fittest*—were revealed to Darwin (and even before him to the unassuming Wallace) not only from extensive observation or investigation of scientific facts but upon perusing an *Essay on the Principles of Population as it affects the Future Improvement of Society*, by the writer Thomas Robert Malthus (1798). Malthus argued somewhat along these lines: that if all those born were to survive and have progeny they would multiply in geometrical progression and the earth would be so thickly populated as scarcely to allow one room to stand with arms akimbo. And yet the world's population has until recently remained more or less stationary. What are the factors responsible for this limitation? Malthus came to the conclusion that there was a natural process of sifting, one of the most potent causes controlling populations being food supply. However prosperous or prolific a community or a nation might be, if the increase in the staple diet cannot correspondingly keep pace with general prosperity and the increase in numbers, a limit would be automatically set to its numerical expansion, while war and pestilence further help keep the balance. Only those who are well fitted in the struggle for existence survive—the others go by the board. Darwin and Wallace were both inspired by the idea. They argued that if these principles could apply to the

Browns of Barrow and the Baruas of Burra Bazar, they could be equally true of the beetles in your backyard, the tadpole in the village pond, the heather on the down, the moss on the fell, the fawn in the glade and even to the reptile lurking in some sly dark niche; in short to the entire organic world. The Forces that be, do not fashion the same destiny for all : there is extinction for the multitude and survival for the few—the few who adapt themselves to environment and the rigours of competition.

Inherent Momentum in Evolution

We shall now deal with the various other theories of evolution. According to the view held by many scientists, there is an inherent *Momentum* in Evolution. This implies that once an animal group has started on a certain evolutionary line, and in a certain direction, it must follow that road and that direction to the bitter end, and meet its doom, perhaps as a result of over-specialisation. In other words, the very features to whose presence the success of a race or a species was due, like the convolutions in the shell of an ammonite (Cephalopoda) the increasing size of the elephant's tusks, or of the canine teeth of the extinct Indian sabre-toothed tiger, became by progressive development (which the animal could not check on account of evolutionary momentum) detrimental to the very existence of these organic beings, and they finally perished. For it is obvious that the tusks of an elephant or the canine teeth of a tiger served both as offensive and defensive weapons only up to a certain optimum size, and if they grew longer, far from being a source of protection, they became an actual hindrance to the animal, since they restricted its movement both in attack and escape.

There is also the very remarkable case of the (bivalve) sea-shell, *Hippurites*, which flourished in the Cretaceous seas of the Mediterranean region, and which acquired momentum for excessive deposition of carbonate of lime in its shell. The result was that the space within the shell in which the animal lived, became so restricted that there was little room left for the animal itself, and it was finally ousted from its own house, as it were, probably because it was unable to check this tendency owing to some inherent urge or momentum in its development. This led to its ultimate extinction.

Lamarck's Theory of Use and Disuse: Views of a Soldier-Scientist

An ingenious idea was put forward by the French savant Lamarck—botanist, zoologist, palaeontologist, geologist and soldier in one—to explain the changes undergone by living beings in their physical make-up. It is common experience that a machine if left idle soon rusts, while in spite of wear and tear, the same machine keeps in good condition when in continuous use. Indeed if not required, it might be even better to lend it to someone who will keep it running (provided of course you are sure of its being returned) than let it stay idle over a long period. In the same manner, Lamarck argued that if a living organism did not, or due to changed surroundings could not, keep any part of its body in continuous use, that part would degenerate in course of time, but that if a part was kept in use it would improve in utility. He gave the classical example of the giraffe's long neck and expressed the view that successive ancestors of this quaint animal were forced to stretch their necks to reach foliage on tall trees since the low-growing shrubs and grasses upon which their ancestors had fed, disappeared owing to climatic changes. Being subjected to perpetual craning, the giraffe's neck increased in length in a sheer struggle to help its owner feed and survive. Lamarck argued that the cumulative effect of such acquired changes would in course of time so radically modify the appearance of the animal as to constitute a new species.

It is true that Lamarck's ideas on evolution and the origin of species do not find favour with the majority of biologists today. His opponents argue that *Acquired Characters* cannot be inherited by the offspring and become progressively accentuated from generation to generation. They assert, for example, that if you chop off the tails of mice generation after generation they will still produce mice with tails, "taillessness" in this case being an acquired character. In doing so they overlook that such taillessness is an *artificial* mutilation, and not a change brought about by the *manner of living* of the animal itself. Whether or not Lamarck's ideas regarding the *modus operandi* of evolution are acceptable today, there is no doubt that this scientist, who was old enough to father Darwin when his

classic *Philosophie Zoologique*, was first published in 1809, ranks as an outstanding genius. He was in fact one of the first to put forward the idea of uniformity or gradual change as opposed to the Cataclysmal Theory of Creation (see p. 40) which was more commonly upheld during his times.

As palaeontologists we believe that in spite of strong opposition to his viewpoint, amounting at one time almost to derision, Lamarck's ideas were fundamentally sound ; for it is indeed difficult to differentiate between strictly inherited and acquired characters. And if Darwin's *Natural Selection* came to the forefront, it was not because Lamarck's theory rested on a frail basis but because even during Darwin's time problems of heredity, descent and mutations were still imperfectly understood.

It is no small homage to this savant that, afflicted with malady and ending his years in blindness, he remains one of the foremost authorities on the invertebrate group of animals.

Evolution by Mutation

In order to give a complete picture of evolutionary processes, let us state other current views about them. According to one school of thought (experiment and critical observation always form the basis of scientific views), new forms of life may arise by sudden changes. Thus, in addition to the gradual, progressive and adaptive processes of evolution there are the sudden changes in the constitution of the germ plasm of the cells which result in *Mutations*, or forms which look manifestly different from their parents and which arise for no obvious reason. They may give rise to new species if their progeny in turn inherits the new characters, which are thus perpetuated in the race.

Mutations Artificially Produced

It is definitely known that mutations can be artificially produced in some of the lower animals. Thus a beetle named *Leptinotarsa*, when subjected to exceptionally hot and dry conditions at a particular stage of its development, produces individuals which are quite different from the normal offspring. That these variants are true mutations is established by the fact that when they breed under normal conditions, the hybrids produce young

resembling themselves and the parent in the right Mendelian[1] proportions, and a fixed proportion among them *breed true*, that is, produce young exactly resembling themselves.

Discoveries of this kind are obviously of great significance, for if by experiment we should be able to produce a new type of beetle or a particularly luscious variety of apple, there is theoretically no earthly reason why, by subjecting human beings to extremes of heat or cold, or alternately both, or by dipping them in tubs, instead of sending them to tutors, we might not one day succeed in producing reasonably intelligent individuals, though the probability of producing idiots must not be overlooked either. There are here the possibilities of improving the characters of our species, provided a policy of deliberate breeding is adopted.

It is well known that science has been able to control the sex of offspring of certain species of animals (that is, to produce male or female young at will) by feeding them on certain diets, or by placing them in particular types of media. This is not so strange considering that the oyster changes its sex year in and year out as a matter of routine, while the female of the swordtail fish becomes a male after being a good mother for three years in succession. It is said that this happens because the female population is far in excess of the males. We need scarcely mention the case of the medieval Swiss cock who was publicly tried in Basle for laying an egg, and was actually burnt at the stake for his ignominious behaviour! This merely proves that the organic system is quite plastic and capable of being influenced a great deal by environment. It should, however, be noted that matters are more complex in the human species, and that science is still far from having found a proven means of influencing the sex of human children.

Man's Origin by Mutation—a Possibility ?

It is believed by some that man himself is a mutation of some highly evolved ape, and that this metamorphosis

[1] G.J. Mendel (1822-1884) was Abbot of the Königskloster at Brünn and made a series of experiments on the cross-breeding of the tall and dwarf varieties of green peas. His writings were buried for forty years in the volumes of a local Society and came to light in 1900. His experiments showed that all the hybrids were tall, but when bred among themselves, three-quarters of the progeny were tall and one quarter dwarfs. These dwarfs bred true, but the talls produced pure dwarfs, pure talls and mixed talls.

was connected with the (geologically) sudden uplift of the Himalayas which not only isolated these apes under conditions of severe cold and hardship, but which also destroyed the vegetation, and with it the foods on which the apes normally subsisted. This brought about a change in their physical make-up. The sequence of events appears to have been as follows. The closing chapter of the Miocene period, heralding the dawn of a dry and cold era in geological history, finally culminated after the Pliocene, in the Great Ice Age. The higher plateau regions north of the Himalayas lost their forests owing to climatic changes and the unfortunate apes thus isolated had to shift for themselves as best they could. In other words, as a consequence of sudden physiographic changes, these apes, forced to adapt themselves to a new type of food, a new mode of existence involving living on the ground under conditions of severe cold instead of on tree tops, acquired a sudden burst of intelligence and certain man-like physical characteristics. By further gradual modification, the ape-like beings finally turned into man !

Evolutionary Changes due to Isolation

Isolation is an important factor in the evolution of new species. We stated earlier that marked geographical changes have taken place during the course of geological history. Thus the island-continent of Australia and the Javanese islands were at one time a part of the Asian mainland, just as Ceylon was physically united to the Indian continent. So were a host of other islands. They were separated from the mainland by the operation of geological forces such as rise in the sea level, and the natural processes of denudation and erosion. As a consequence, their fauna and flora also became isolated from their original parent assemblages with the result that these islands now possess animal and plant life peculiar to themselves, and have evolved many species that are not found on the mainland. The kangaroo is a classical example, and is confined to Australia, that island-continent having remained separated from the rest of the world since late Mesozoic times. Some islands have, however, come into existence quite independently of the present land areas. Such are the islands of volcanic origin. Because of lack of direct communication with each other they sometimes have well differentiated animal and plant life.

The most spectacular case of isolation in relation to evolution is that of the Galapagos archipelago, each one of whose islands boasts of its own characteristic animal species, for instance of finch-like birds and particularly of tortoises. Indeed the archipelago was named from *galapagos*, the Spanish for tortoise. The exact nature of these islands is not known and some consider them to be of volcanic origin. However that may be, it seems certain that at one time all the islands were united with each other and probably with the mainland of South America. Thus while the species inhabiting them are all distinct because interbreeding has been impossible for a long time, yet a manifest similarity runs through them, and they have retained evidence of their common origin.

Separation by sea-barriers is not the only means by which isolation results. Great mountain ranges straddling the face of the earth, or submarine ridges sometimes rivalling mountain ranges in size and peeping above the waters as oceanic islands, effectively isolate flora and fauna, in the first case of the land, in the second of the sea. Vast sheets of inland waters like the Caspian and the Black Seas, once in free communication with the ocean water of olden days but now isolated by land barriers, contain elements of marine fauna peculiar to themselves. Likewise, the Mediterranean and the Red Seas, which have been separated over a very long period, possess distinctive faunas.

Climatic changes may also isolate regions that were originally subject to much the same meteorological conditions in the remote geological past. Thus the region between the Himalayas and the Nilgiri hills in South India, once within the orbit of cold conditions though not subjected to actual glaciation, now possesses a much warmer climate, and its animal and plant life is altogether different from that of the Nilgiris and the Himalayas. The past climatic continuity of these widely separated areas is, however, proved by the fact that a species of *Rhododendron* and the goat *Hemitragus* occurring in the Nilgiris are both definitely a part of present day Himalayan life. We shall refer to this point again when dealing with the Pleistocene of Ceylon.

We might cite an even more interesting instance—one that intimately concerns the human species, namely, isolation as the result of mass immigration of populations. It is believed that the modern American, separated from his original homeland in

Europe is gradually acquiring a type of physiognomy which includes some features of the American Indian. Long domicile in a particular region must leave its impress.

Sexual Selection

Another important factor which, apart from its bearing upon evolutionary changes, might even determine the survival of the lineage is *Sexual Selection*,—the struggle to acquire a mate. In other words "the struggle for wife" might actually mean "the struggle for life". But the acquisition of the mate is not even half the battle. There are so many other hurdles to be crossed.

In the story of human life, as indeed of all life, the struggle for survival begins early. Although the number of human male sperms presented in a single episode is 225,000,000, (a million and a quarter more than half the population of India) only one of these has the chance to merge with the female egg. Apart from this, they have many other obstacles to encounter—for, says J. D. Ratcliff, "odds against success for these mites of life are 225,000,000 to 1," while according to Alan Frank Guttmacher of Johns Hopkins, "The baby that the germ cell engenders has a far greater chance of becoming President of the United States than the cell ever had of becoming a baby." Of course there is another way of looking at all this: Nature, though prolific, even to the extent of being often utterly wasteful, takes no chances and therefore produces spores, sperms, etc., literally by the million to try to ensure perpetuity of the race.

Earth-Movements and Climate as Factors in Evolution

According to the distinguished American geologist Lull, the heart of this great planet has pulsated and throbbed as if with life, since the dawn of primaeval day, and its pulsations have influenced the rise and fall of organic beings since their first appearance upon it. In other words, mighty revolutions, climatic and physical, which were experienced by the globe, and which have often produced widespread geographical changes, have also influenced life profoundly and left their impress upon it. To quote his own words, "As the physician, by a clever device can record graphically the pulsations in the blood-stream which are synchronous with the throbbing of the human

heart, so I have drawn a curve to show the correspondence between the pulse of life and the heavings of the earth's broad breast." It would thus appear that important landmarks in organic evolution, like the origin of the fishes, reptiles and mammals, to take a few instances, and the simultaneous decline of other groups, synchronised with changes of a far-reaching character upon the globe, and were perhaps the direct result of these changes. In a small work like the present one we cannot go into much detail, but some examples mentioned by Lull may be given.

It is known that during the Proterozoic era, preceding the first recorded (Ordovician) vertebrates (fishes), the earth experienced extensive earth-movements and glacial conditions. Therefore it is surmised that the rise of the vertebrates was connected with these changes. The rise of the mammals, probably in the Permian but certainly in the Upper Trias, is likewise connected with another period of earth-movement during late Carboniferous times, followed by glacial conditions in the early Permian.

It is perfectly conceivable that the various groups of the Plant Kingdom were similarly affected by the physical revolutions upon the globe, but space does not permit us to discuss them here.

EVOLUTION IN EVERYDAY LIFE

The Impact of Environment on Man and Machines

The struggle for existence is not confined to animals living under natural conditions, but even the human race—individuals, communities and nations—are all engulfed in it. The race that by force of circumstance is unable to withstand the impact of, or competition with, another race, must perish : witness the almost total extinction of the American Indian, of the aboriginal Australian, and the subjugation of the Proto-Dravidians by the Dravidians and, in turn, of the Dravidian race by the taller, fairer, hawk-eyed, sharp-nosed Aryans.

The community that lacks cohesion, that looks to safeguards for its very existence, that learns to depend upon a crutch, that gains 'success' by the sacrifice of others (to which history bears witness); that is, in short, a passive spectator in the struggle for existence, must become degenerate in course of time, and

perish. Read the history of any country, of any nation, of any community, and you will see the sign writ large upon the wall. If legislators and leaders of men and nations would ever bear in mind the principles of organic evolution, they would serve their communities and their countries far better than they do today. If they would only consult an humble fossil shell instead of confining themselves to voluminous treatises on political science, history or international law, they would make the world a much happier place to live in.

We believe that the survival of the Indian culture when the glorious Greek and Roman civilisations perished, is largely due to the extreme adaptability of the Indian to change of environment, his capacity to face adversity, helped by his philosophic outlook and religious and mental make-up, and to the simplicity of his way of life. Were it not so, it is scarcely believable that we could have survived as a nation after the shattering impacts of foreign invasions and long periods of alien domination.

To come back to the point; these evolutionary processes are such that nothing can escape them; the automobile, the push-cart and even the bicycle model that cannot keep pace with the changing environment must become a back number. In fact, the modifications that vehicles have undergone constitute one of the most striking episodes in industrial evolution (Fig. 28).

During the days when industrialisation had just begun in Europe, when men still wore frock coats and women crinolines, in which they were expected to faint when proposed to, the cumbersome high-wheeled tricycle (a modification, in a way, of the four-wheeled cart) was good enough. The four-wheeled cart, it may be mentioned, is itself an offspring of the two-wheeled cart and was no doubt evolved with the concomitant improvement in roads. At all events, though the tricycle moved at tortoise pace, some people must have looked askance at it for its dangerous speed. Well, times changed, and so did the tricycle. The high-wheeled, low-speed monster gave place to smaller-wheeled and faster models. From the high-wheeled tricycle were evolved more or less in succession, the hobbyhorse, the bone-shaker, and gradually the modern type of bicycle which last, being faster and better adapted to the prevailing conditions, was more successful in this struggle and has,

therefore, survived (Fig. 28 *d*). The others, unmatched with the changed environment, have become extinct.

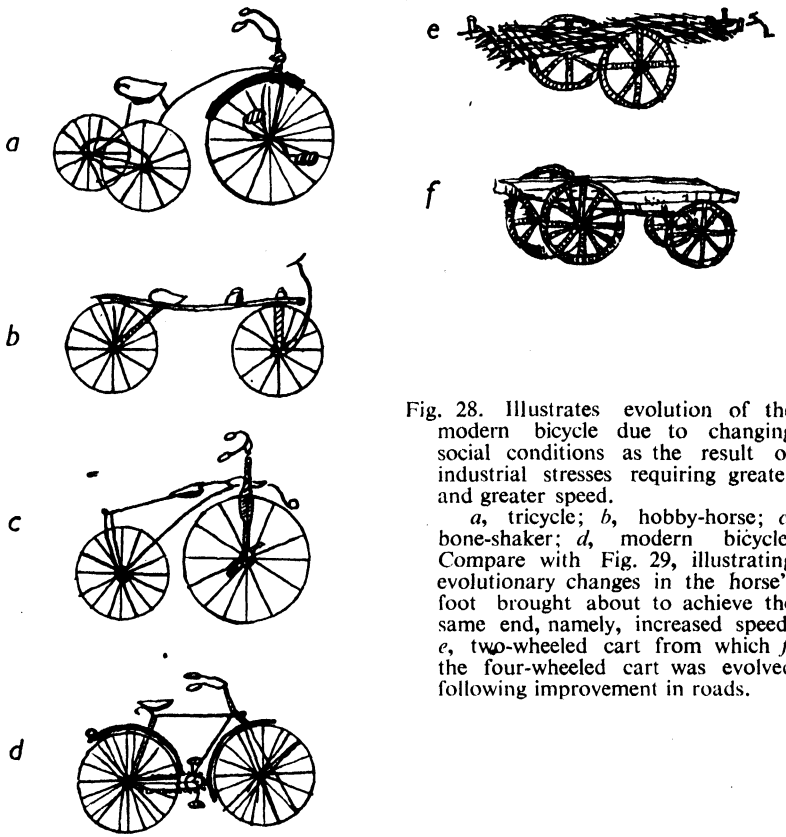


Fig. 28. Illustrates evolution of the modern bicycle due to changing social conditions as the result of industrial stresses requiring greater and greater speed.
a, tricycle; *b*, hobby-horse; *c*, bone-shaker; *d*, modern bicycle. Compare with Fig. 29, illustrating evolutionary changes in the horse's foot brought about to achieve the same end, namely, increased speed. *e*, two-wheeled cart from which *f*, the four-wheeled cart was evolved following improvement in roads.

Similarly, in another direction, with every turn of the industrial wheel, the length of ladies' dresses and their tresses shrank by a fraction, giving greater freedom and scope for movement, both symbolic of the age. The tempo of life, with increasing industrial expansion, became faster and neither the long tresses nor the long skirt could keep pace with it. The struggle for existence ultimately proved too much for them and they became practically extinct, giving place to shorter and more convenient modes. From the long tresses were similarly evolved by progressive attenuation, the bob and the shingle, so much so that at one stage, where the shingle was coupled with

another masculine adaptation, the slacks, it became difficult to distinguish between the male and the female of the species. However, this masculine adaptation by feminine vanity has played an unsuccessful role in western life. The reason is obvious. The human male, in spite of his superficial desire for modernity, appreciates at heart the feminine qualities in the gentler sex, not masculinity, however unobtrusive. And woman, with her fine intuition into such matters, has been quick to understand it. She has relegated to the background an adaptation which proved, in biological parlance, unsuccessful in the struggle to acquire a mate, a phase which deep down masks the struggle for existence, not only of the individual, but also of the race.

Evolution of the Horse : A Classical Example of Progressive Evolution

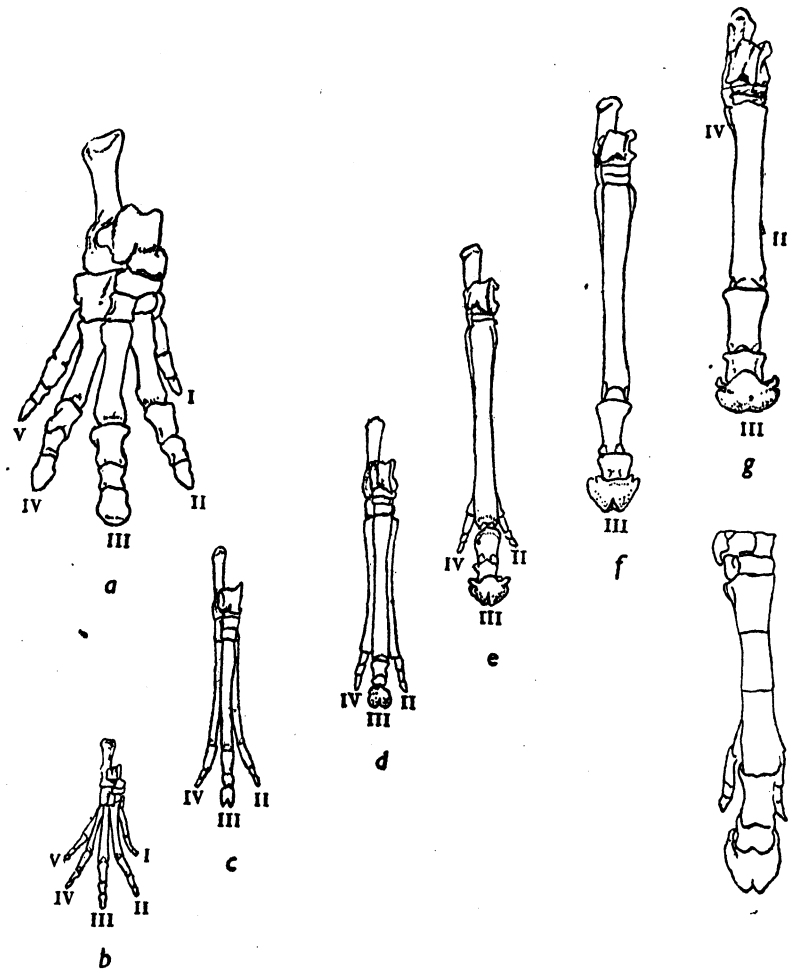
Because of its importance (but despite its digressive nature) we crave the reader's indulgence to pursue the subject of evolution a little further in another direction, for it lends us insight into an important phase of evolutionary processes.

Amongst organic beings, the finest example of progressive evolution and natural selection is furnished by the Horse, whose fossil remains have been found in series showing evolutionary changes in a definite direction, in rocks of Tertiary age, from the Eocene onwards. These fossils are indeed unequalled in the annals of vertebrate palaeontology for their perfection and interest, and they throw a flood of light upon the evolution of organic beings in general. Not only that : a study of this remarkable series of fossils and a parallel study of the climatic and physiographic changes that took place on the North American continent during the Tertiary era, tell us of the fascinating manner in which the evolution of the horse family progressed parallel with these physiographic changes, and how its evolution was closely linked with such changes. Perhaps the most important of these modifications was the reduction in the number of the horse's toes during the course of its evolution.

Five-toed Ancestors ; Reduction in the Number of Toes in the Horse Family

It is believed that the forerunners of the horse were animals like the five-toed *Euprotogonia* (Figs. 29*a*) belonging to the

extinct group of the Condylarthra, which flourished in the



Figs. 29. Skeletons of the foot of the early horses and of the Eocene Condylarthra, probable ancestors of the horse.

a, *Euprotogonia* and *b*, *Phenacodus* (Condylarthra); *c-g*, stages in the evolution of the horse's foot from three-toed to single-toed forms; *c*, *Eohippus*; *d*, *Mesohippus*; *e*, *Hipparion*; *f*, *Pliohippus* and *g*, *Equus* or modern horse (After Graham Kerr); *h*, Indian three-toed horse, *Hipparion theobaldi*, also found in W. Pakistan.

North American continent and earlier (during the Lower Eocene) in Asia; or they may have been forms resembling

Phenacodus (Fig. 29*b*), also one of the Condylarthra but bigger in size than *Euprotogonia*. Cope who first discovered *Phenacodus* regarded it as the actual ancestor of the horse lineage, but according to Romer this is unlikely as *Phenacodus* was itself contemporaneous with, and larger than, the four-toed horse, *Eohippus*.

This primitive first known horse, *Eohippus* (Fig. 29*c*), lived in Asia, Great Britain and America[1] in early Eocene times, that is at the commencement of the Tertiary era. It appears to have reached the North American continent, its main theatre of evolution, via an old land-connection across the present Bering Straits. Though it was decidedly on the horse line, *Eohippus* was a very tiny individual, being less than a foot in height, and resembled a sleek racing dog more than a horse. It possessed four working toes in its front foot and only three in its hind foot. The fifth toe in the front foot still existed, but it had become useless, and persisted only as a vestigial structure.

The further story of the evolution of the horse is the story of the numerical reduction of its toes through various intermediate stages, in an attempt to gain more speed. This may be compared (if it is permissible to stretch a point) to the parallel reduction in the number of wheels during the course of evolution : the four-wheeled cart followed, first by the three-wheeled tricycle, and then by the two-wheeled bicycle (not to speak of the motor cycle), the objective being essentially similar in all cases, namely, increased speed.

Eohippus was followed in Oligocene times by another horse named *Mesohippus* (Fig. 29*d*), like, shall we say, the four-wheeled cart by the three-wheeled tricycle. It possessed only three toes in its hind foot as also in its fore foot (the fourth toe having become vestigial and, therefore, useless) with the middle toe, which was to become the hoof of the modern horse, better developed than the side toes. But all the toes still touched the ground at times. *Mesohippus* was larger than *Eohippus*, standing about two feet in height.

Mesohippus was followed in the next geological period, the Miocene, by horses like *Protohippus* which, though having three

[1]It must be pointed out that at that remote period the configuration of these lands was quite different to what it is today. And when we refer to these countries by name in this context, we merely wish to give the reader a broad visual conception of the areas that we are speaking of.

toes in both the hind and fore feet, had the middle toe developed to such an extent that it alone touched the ground, while the pair of side toes stood well above the middle toe. At the same time, *Protohippus* showed an improvement in size and speed over *Mesohippus* and stood about three feet high. Though the simile is not complete, this stage may be compared to the bicycle, a definite improvement upon the tricycle.

Another horse, a near relative of *Protohippus*, was the Miocene *Merychippus*. It is believed that this horse is in the direct line of descent of the modern horse that has contributed so much to human happiness and comfort, and has played such a fine role in the life and romance of man. Indeed, but for the horse, history had presented a different panorama. There might have been no Alexander, no Caesar, no Crusaders, neither Shivaji nor Napoleon. And what is of more human interest, the course of many a romantic episode might have run differently !

Another three-toed horse was the well-known *Hipparion* (Fig. 29 *e*) The Indo-Pakistan contemporary of this horse was *Hipparion theobaldi* (Fig. 29 *h*) that roamed the northern parts of the continent, particularly along the present region of the Himalayan foot-hills before these were upraised. Fossil remains of this *Hipparion* are found in the Siwalik rocks and many fine specimens of its molars and two hooves are preserved in the Museum of the Geological Survey of India, at Calcutta. It is believed that the single-toed Indian *Hipparion* gave rise to the Zebra.

In the next geological period, the Pliocene, or even earlier, the first one-toed horse, *Pliohippus* (Fig. 29 *f*), appeared. It was a direct offshoot of *Merychippus* and still retained vestigial side toes.

Finally the genus *Equus* (Fig. 29 *g*), to which the swift-moving modern horse belongs, appeared in America during the Pleistocene. It lived both in Europe and parts of Asia though, as we shall see presently, *it had disappeared completely from the American region before the arrival of the Europeans.* They introduced it, this time as a domestic animal and it ran wild again in its ancestral home ! The *Equus* stage may be compared (though the simile is again not complete) with the final product of evolution of the cart, namely, the motor cycle, the speediest vehicle in its line, like the modern horse with a single hoof, in his.

It is of interest to record that the modern one-toed horse

has sometimes been known to produce (as an abnormality) young with three toes, thus indicating the descent of *Equus* from one of the three-toed forerunners. It is said that Julius Caesar rode on one of these three-toed horses. It would indeed be worth while unearthing its remains for biological examination, if only to see what impress the great Caesar left upon it!

Physiographic and Climatic Changes responsible for Reduction in the Number of Toes

It is remarkable that the change in the number of toes (and in the structure of the teeth, with which we shall not deal here) was connected with the change in the physical conditions from the Eocene to the Pleistocene times, which we shall now briefly review.

During the Eocene period when *Eohippus* lived, North America, the early homeland of the horse, was a forest-clad region abounding in fresh-water lakes and rivers. The spreading five toes of the ancestral *Euprotogonia*- or *Phenacodus*-like forms, or the four toes of the *Eohippus*, were suitable for locomotion in such a habitat, otherwise the feet would sink into the soft swampy soil.

Gradually dry conditions began to prevail in that region, in the Oligocene, and the thick swampy forests gave place to dry woodland and more open ground. Swift movement was thus not only possible but necessary, especially for escape from marauding animals that lived contemporaneously with the horse. This meant that only those of the horse family which could thrive on the coarser grasses, and which acquired high speed by the modification of their toes, survived, while other lineages, unable to compete or adapt themselves to the new conditions, perished.

In the Miocene, (when the major uplift of the Himalayas also took place) Western America was uplifted into a plateau, and mountain ranges were developed. These cut off the prevailing westerly winds and with them also the moisture that they bore. The forest growth dwindled still further and gave place to wide open plains, hence swift movement became still more imperative for self-protection. It was thus during the Miocene that the first incentive was given towards the evolution of the one-toed

horse; and even though the Miocene horses were all three-toed, the side toes generally appear to have served no useful purpose.

In the Pliocene and Pleistocene, physiographic conditions continued to be on the dry side and vast grass-lands dominated the landscape. This made further evolution possible. Thus in the Pliocene, the one-toed horse made its first appearance and attained a fair measure of success. In the Pleistocene, the horse became much superior in size and speed to its Pliocene predecessors.

Strange though it may seem, after its varied development, the horse became finally extinct in America. Whether this was a consequence of the intense cold of the Glacial epoch or some fell disease such as affects horses and cattle today, we cannot tell. But this much is certain, that the horse disappeared from America but survived in Asia. The complete disappearance of the horse from America at the end of the Pleistocene after its many and varied ancestors had flourished in that region for several million years is one of the riddles of evolution for which no adequate explanation can yet be given.

Evolution in Reverse Gear

We have earlier defined evolution as progressive, or moving forward. However, like the modern car placed in reverse gear, the vehicle of evolution sometimes moves retrogressively, i.e., backward, instead of forward. The simile between the vehicle of evolution and the modern petrol-run vehicle can be pushed even further, for they are both self-starters. There is, however, one difference : that while the latter can be checked by an intelligent driver, the wheels of evolution, like the Wheels of Fate, cannot be so checked.

It would take too much of our space to dilate upon this subject, but many beautiful examples are known where a race, after evolving along a certain line for several million years, has found the final experiment unsuccessful, and then engaged the reverse gear, even like a motorist who has unsuccessfully tried a short-cut along an impassable by-road and has then had to reverse !

One remarkable example of evolution in reverse gear has already been given, namely, that of a potato-like individual among the tunicates, permanently fixed to a rock, but descended

from a lively, free-moving tadpole-like ancestor (see p. 47). This ancestor is still reproduced each time in the young larva of the tunicates (Figs. 10 *b,c*) which swims about in the sea before attaching itself to some object and changing into the 'sea-potato'. These changes, however, take place at phenomenal speed, in the course of a few hours.

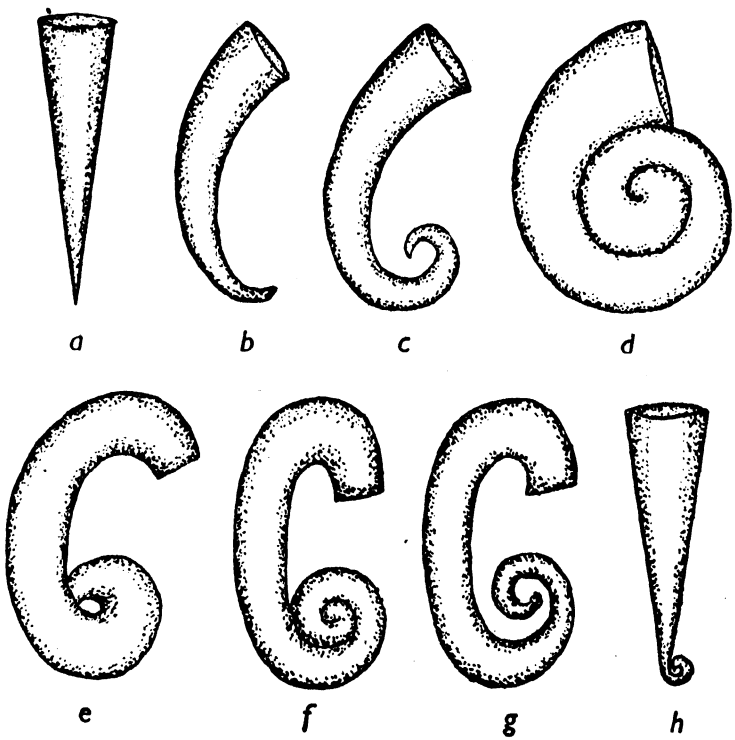


Fig. 30. Entirely diagrammatic sketches of various cephalopods illustrating evolution in forward and reverse gears.
a-d, evolution in forward gear (gradual coiling); *e-h*, evolution in reverse gear (gradual uncoiling). After millions of years an almost straight, conical form *h*, with which this group began its existence, was produced.

A most interesting example of evolution in the forward gear followed by evolution in reverse gear is furnished by the group of marine shelly animals belonging to the Cephalopoda (Fig. 30). Members of this group commenced life as straight cones (Fig. 30 *a*) in the early part of the Palaeozoic era, but soon

developed a tendency to coil. They first became horn-shaped (semi-coiled), then by gradual stages they assumed a completely coiled form, and finally, this tendency became so pronounced that in some of the more advanced species, only the last whorl of the coil was visible. This experiment continued for millions of years, but its final stage (complete coiling) proved a failure and, at the commencement of the Cretaceous period, they engaged the reverse gear of their evolutionary vehicle. They then gradually commenced uncoiling, passing once again through a similar series of successively less-coiled forms till, finally, after the lapse of several million years, they again assumed the almost straight conical shape of their early ancestors (Fig. 30 *h*). But unfortunately, the reverse gear appears to have been engaged too late, and with but one exception, the entire Class perished at the end of the Cretaceous period. The sudden and almost complete extinction of this animal group which reigned supreme through millions of years, is also one of the many riddles of evolution.

It may interest the reader to know that the solitary survivor referred to above, is the well-known *Nautilus* of the Indian Ocean. It has figured even in poetry, and representations of it appear in the architecture of the India Gate, New Delhi.

The phenomenon figuratively described as 'evolution in reverse gear' must, however, be understood to take place in a very limited sense. For when an organism reverts to its ancestral (primitive) form, it does so only superficially and still retains its own distinctive features. *Irreversibility of Evolution* is, in fact, an established principle, which implies that steps in evolution once taken cannot be retraced, except in a superficial manner. A species once extinct, never recurs.

Unequal Evolution : Origin of Divergent Races of Fossil Man

We have taken pains to stress that there is diversity in evolution. Man is no exception to this law. Thus we find that man has not become progressively more refined in all aspects (physical or moral) from generation to generation, even though, taking the race as a whole, he has possibly shown some improvement. But ancient races are known, to wit the Upper Palaeolithic Cro-Magnons, who were not inferior in physique to the most highly developed modern races, and whose direct descendants are believed to be the stalwart Guanche, cave-dwellers of the

Canary Islands, who lived undisturbed in their Palaeolithic environment until a few hundred years ago.

It is also true that different parts of the body have not evolved at the same rate, for the impact of environment has not been uniform in several different directions at the same time; and there are other equally important factors inherent in the race which have not remained constant. Thus we find that while one race of fossil man possessed, say, limbs comparable in some respects to that of modern man and a skull with many ape-like characteristics, another of a later age possessed legs and arms resembling in several respects, those of the apes, while the skull and jaw were more man-like than one would expect to be associated with an individual possessing such limbs. And if certain evidence is to be relied upon, we know of an extinct human species that combined a modern type of skull with an ape-like jaw. The erect posture found in the Australopithecinae (see p. 212), which was attained earlier in these sub-men than in any definitely known human species, *preceded* the development of the brain. Such diversity of combination is of great interest and importance, and every student of evolution should bear it in mind. Moreover it is becoming increasingly clear, though all authorities do not necessarily accept this view, that some human characteristics which we hitherto regarded as advanced are really primitive. All we can say is that as new facts are coming to light, the picture of evolution is unfolding itself.

The progress of evolution may be likened, say, to that of the Frontier Mail from Bombay to Amritsar, where all passengers do not necessarily travel from the start to the terminus. There are many stations *en route*, where passengers alight, their journey ended. They mark similar terminations on the evolutionary road. But other passengers proceed further, perhaps along certain branch lines leading to various outlying destinations, comparable to other stages in evolution—the journey always coming to an end ! Rarely do passengers travel all the way from Bombay to Amritsar, and, though cases are known, only a few types have travelled their way, so to speak, almost from the very inception of organic existence to the present day.

CHAPTER VI

THE GREAT ICE AGE OR PLEISTOCENE EPOCH IN EUROPE, INDIA, PAKISTAN AND BURMA

THE greatest changes that man has experienced in his physical evolution, and about which we have definite evidence, took place during the Great Ice Age or Pleistocene epoch—the last major subdivision of geological time.

It is perhaps not commonly known that the Ice Age was not a period of one continuous glaciation, but that *it consisted of a number of Glacial phases (when actual ice conditions prevailed) alternating with Interglacial phases, when the climate was more genial.* These conditions obtained in the northern, temperate latitudes and in the high mountainous regions of the southern lands, but in other areas milder conditions prevailed and are defined as Pluvial (Latin, *pluvium*=rain) and Interpluvial, corresponding to the Glacial and Interglacial periods of the glaciated regions. These Pluvial periods were very suitable for early man. As further details will be given when we consider the Ice Age in the Indian continent, Burma and Ceylon, we shall not elaborate the subject here.

EUROPE

Nature of the Evidence :
Glacifluvial and Moraine deposits and River Terraces

Our knowledge of the Great Ice Age was founded upon some remarkable studies on glacifluvial and moraine deposits in Scandinavia and in the Alps, particularly those by two well known glaciologists, Penck and Brückner, in the Alpine region. We shall accordingly give a brief account of their results, for it will enable us to understand the problems connected with the Ice Age in the Indian continent and neighbouring lands, with which we are immediately concerned. It will also enable us to see early man in these regions in his correct chronological perspective.

The formations referred to above, consist of material deposited by streams issuing from sheets of ice and from glaciers (glacifluvial deposits) or of material torn from the valley floor by moving ice and left either at the end of the glacier (terminal moraine) or along its sides (lateral moraine). Before retreating during intervening warmer periods, each advance of ice during the Ice Age left its mark in the form of such deposits across the plains of Europe and in the Alpine region, and each deposit proclaims evidence of a separate episode within the glacial cycle.

The evidence of glacifluvial and moraine deposits naturally relates mainly to glaciated regions, that is, areas actually covered by ice. What then of those regions which were not subject to glacial conditions, such as many parts around the Alps and the whole of the Indian continent south of the Himalayas? The evidence from these regions, distinguished as *Periglacial* (surrounding the glacial, see Fig. 31) reveals a parallel story in their river terraces. This enables us to correlate the evidence from the two regions. In order to clarify these problems of correlation it is essential to explain briefly the significance of river terraces. It is obvious that during the warmer spells, rivers contained sufficient quantities of water to erode their beds. As a result, they left flat areas around their banks high and dry, which erstwhile formed a part of the river-bed. These constitute river terraces, and since they were formed by *erosion* they are known *terraces of degradation.* In contrast to this, deposition took place during the colder phases when the river had less water and comparatively more material in suspension than it could carry. In this way *aggradation terraces* were formed by *deposition.* Such terraces are well seen along mountain rivers, particularly where they debouch into the plains. If the reader has not already noticed them, he can do so while traversing the submontane areas near Kalka, Pathankot, Jammu, Dehra Dun, etc. Indeed, these terraces may be seen even from the train, particularly as one approaches Kalka. Such terraces can also be seen along the Indus, Jhelum and Sohan rivers in Pakistan, along the Irrawaddy and other rivers in Burma and along the rivers traversing the peneplains of Ceylon.

A fact which needs emphasis is that in each river system the higher terraces are successively *older* than the lower ones, the

level ground immediately above the existing rivers being the youngest of them all[1]. Palaeolithic and Neolithic man lived on

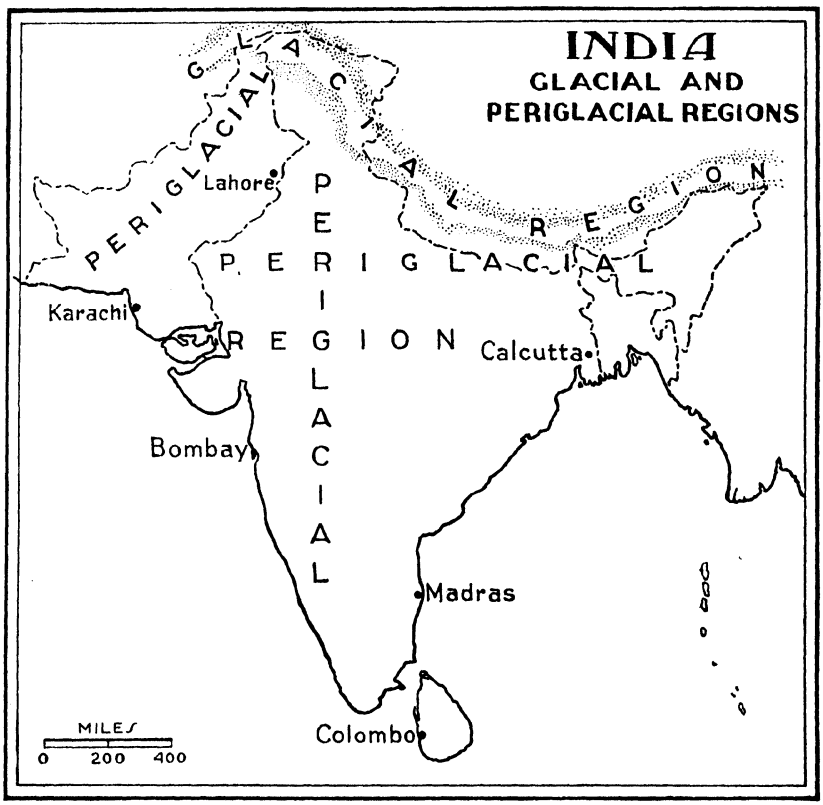


Fig. 31. The *Glacial* regions were actually covered by ice during the Great Ice Age, while more genial conditions prevailed in the *Periglacial* regions.

these terraces because water and materials for making stone tools were plentiful. It is thus possible to date the fossil remains of man, his implements as well as the animals that he hunted and brought home for food, for they all lie buried together in the silts and gravels of these terraces.

[1]This position is the *reverse* of that which obtains in a normal geological sequence where each higher bed is successively *younger* than the underlying one (see p. 17).

By means of these fossil remains and other evidence, it has been possible to correlate the climatic changes which resulted in the formation of these terraces, with corresponding Glacial and Interglacial phases of the glaciated areas, for the glacial moraines merge into terraces of like date. In this way a connected story has been built up which tells us of the sequence of events in the glacial and the surrounding periglacial regions. Details of this story we shall now briefly relate.

The Alpine Region

In Europe we have by now a fairly complete picture of the Pleistocene epoch, but so far as the Indian continent, Burma and Ceylon are concerned our knowledge is still meagre, though much advance has been made during the last two or three decades. In order to give a satisfactory account of the Ice Age of these regions it is essential to deal first with the Pleistocene of Europe where the record is far more complete.

Upon the basis of evidence afforded by the glacifluvial deposits which occur in four terraces, Penck and Brückner distinguished four glaciations in the Alps. This conclusion has been arrived at because these deposits actually grade into the moraines of four major glaciations, namely, Würm, Riss, Mindel and Günz, in descending order. Each of these is separated by warmer Interglacial periods. The equivalents of the well-known Villafranchian subdivision which constitutes the base of the Pleistocene sequence and which in many places contains the first *Equus* (horse), *Elephas* (elephant) and *Bos* (bison), occur below the Günz stage. The sequence of glaciations given in Fig. 32 obtains in the Alpine region.

Attention may be drawn here to two or three important points. Firstly, that the Great Ice Age consisted of four distinct glaciations separated by interglacial periods. Secondly, the glacial and interglacial periods were not of equal duration, but showed considerable disparity. For example the Second Interglacial period which lasted for 240,000 years according to geological evidence, and 190,000 years according to radiation data, was at least three times as long as either the First or Third Interglacial periods (duration 60,000 years each). For this reason,

PERIODS	SUBDIVISIONS ALPINE AREA	EQUIVALENTS
HOLOCENE	POST-GLACIAL	POST-GLACIAL
UPPER PLEISTOCENE	WÜRM { Cold phase / Warm phase / Cold phase / Warm phase / Cold phase }	FOURTH GLACIAL
	LAST INTERGLACIAL	THIRD INTERGLACIAL
MIDDLE PLEISTOCENE	RISS { Cold phase / Warm phase / Cold phase }	THIRD GLACIAL
	GREAT INTERGLACIAL	SECOND INTERGLACIAL
LOWER PLEISTOCENE	MINDEL { Cold phase / Warm phase / Cold phase }	SECOND GLACIAL
	FIRST INTERGLACIAL	FIRST INTERGLACIAL
	GÜNZ { Cold phase / Warm phase / Cold phase }	FIRST GLACIAL
VILLAFRANCHIAN	DONAU STAGES ETC.	

Fig. 32. Subdivisions of the European Pleistocene. The terms 'Cold phase' and 'Warm phase' are intended to express only the *relative* intensities of climate. (Adapted from Zeuner)

the Second Interglacial is sometimes spoken of as the Great Interglacial. Lastly, that *even the above-mentioned subdivisions (Glacial periods) suffered minor climatic fluctuations within their own span.* Thus detailed work has shown that the Fourth Glacial was broken up by two intervening periods (known as '*Interstadials*') when somewhat higher temperatures prevailed, as shown in Fig. 33, where LGI 1, LGI 2, LGI 3, represent cold (glacial) *phases* within the Fourth Glacial (Würm).

PERIOD	SUBDIVISIONS	CLIMATE
LAST GLACIAL OR WÜRM	LGI 3	GLACIAL WET AND COLD
	INTERSTADIAL	TEMPERATE COLD
	LGI 2	GLACIAL
	INTERSTADIAL	COLD MODERATELY WARM COLD
	LGI 1	GLACIAL
LAST INTERGLACIAL		COLD MODERATELY WARM

Fig. 33. Showing climatic fluctuations *within* the Last or Fourth Glaciation, corresponding to Würm. (Based on a section in North England by Armstrong). Not to scale.

Dividing Lines between the Great Ice Age and Recent and Tertiary Times

The Pleistocene merges insensibly into the Recent Period. The line separating the Ice Age from Recent Times is, by its very nature, indefinable. And, indeed, it will be obvious from a more detailed consideration of the problem that, taking the epoch as a whole, we may even regard our own times as being part of the Great Ice Age. After experiencing one of these periods of intense cold—the Last Glacial—we are now passing through a warm phase which is perhaps merely an Interglacial period that commenced about 15,000 years ago. It would not be at all surprising if yet another period of ice formation should set in some thousands of years hence—though who will live to tell the story, no one can say.

The boundary between the Tertiary and the Great Ice Age (a chronological boundary like that, say, between the Mughal and the British periods of Indian history) is similarly indefinite. Therefore a difference of opinion exists as to whether the first glaciation should be regarded as marking the beginning of the Pleistocene or whether the boundary should be drawn earlier. The latter view now prevails. Accordingly, one of the earliest known

fossil men, the Java ape-man, once assigned to the Upper Pliocene (Tertiary), is now regarded as having lived during the early part of the Lower Pleistocene and he may have survived into the Middle Pleistocene. But it is obvious that in a way the point is of no intrinsic importance, for much depends upon where we choose to draw the dividing line between the two epochs, which is more or less a matter of convention. In any case, it is now held that the first appearance of the true elephant, *Elephas*, of the modern horse, *Equus*, and of *Bos* which includes the bovines such as bison, and true cattle, marks the commencement of the Ice Age from the palaeontological point of view. The fauna containing these occurs universally in Europe, India, Africa, China, etc., and is known as the Villafranchian. In India, the first camels (*Camelus*) too, appear at this horizon. Also, this sudden introduction of a new fauna, constituting a fundamental change from that of the Pliocene, coincides with an equally marked climatic change, for the mild conditions obtaining in the Pliocene are replaced for the first time by colder conditions. Moreover, (and this is in some ways most important), further uplift of the now mountainous parts of India occurred during this period, causing a physical break between the Pliocene and younger rocks.

For the purpose of this work, and without going into controversial details, we may accept the chronology or subdivisions of the Glacial epoch given in the Table on p. 101. This will enable us to understand the order in which different fossil men have appeared on the face of the earth, and the climatic and other physical conditions obtaining during their evolution.

Early man existed not only during the warmer spells of the Ice Age—the Interglacial epochs—but also during periods of intense refrigeration. His survival, when so many groups of the larger mammals perished, was no doubt due to his greater adaptability and intelligence, which was probably accentuated by the severity of competition initiated since the day his ancestors left the tree-tops to live in the open country surrounding their forest home.

Furthermore it is important to realize that while glacial conditions obtained in the higher latitudes, the tropical zones enjoyed quite genial conditions, mainly with increased rainfall. For this reason one speaks of Pluvials and Interpluvials, corresponding

respectively to the Glacials and Interglacials in the colder zones. Early man flourished during the Pluvial periods. Detailed reference to these will be made while dealing with the Pleistocene of India and the neighbouring lands.

Did Man exist before the Glacial Epoch ?

While the known facts of human evolution, based upon actual fossil remains of man, relate mainly to the Great Ice Age, there is indirect evidence that the existence of man dates back to a much more remote era, the Tertiary. What then is the evidence adduced in favour of this ? As the question is of prime importance in man's evolutionary history, it deserves careful consideration.

In the absence of actual fossil remains of man, such evidence can only be of an indirect nature as, for example, stone or bone implements, sculpture or other proof of human industry and workmanship. The question before us, then, is whether such 'implements' as are found were actually shaped by human hands or are the result of mere accident. In many places flints have been found in the Tertiary rocks (e.g. of Europe and the supposed Upper Miocene of Burma) which appear to show traces of human workmanship, while certain bones have also been found with apparent marks of engravings on them. Such flints are called *eoliths* or the 'first implements'. It is, however, remarkable that in not a single case has it been possible to demonstrate beyond any measure of doubt that these are of definitely human origin, for neither the 'eoliths' nor other apparently worked bones are associated with old kitchen hearths or human bones, or with other undoubted human relics.

One instance may, however, be noted, namely, the flint implements found at Fox Hall, near Norwich in England, which are believed to be of late Tertiary age and which are associated with what might be kitchen hearths. Beyond that, it is impossible to assert anything with confidence. In the case of the Burma finds, it has now been proved that the rocks embodying the implements are not of Tertiary age, as previously held, but are as recent as Neolithic.

We may also refer here to the Kanam jaw, assigned to *Homo sapiens*, from certain deposits on the eastern side of Lake

Victoria in Africa. Now if such an advanced type of humanity existed in early Pleistocene times, it follows *ipso facto*, that its ancestors must have lived in still earlier times, possibly in the Pliocene or even as early as the Miocene. However, since an element of doubt still enshrouds the question of the age of this find, no definite opinion can be expressed.

Among the supporters of the human origin of the *eoliths* found in pre-Pleistocene rocks were some well-known scientists of their time, namely G. de Mortillet in France, M. Rutot in Belgium and Reid Moir and Prestwich in England. The theory, however, owes its origin to Abbé Louis Bourgeois of Paris. The idea has been opposed by many and no longer holds the field, for it is asserted that eoliths can be produced by sudden changes of temperature, as in the desert, by flint nodules rubbing against each other, as in certain mills in which chalk and flints are allowed to rotate, or even by pressure exerted by overlying rocks. Moreover it is argued that none of the Tertiary man-like beings, even *Australopithecus*, the human status of which is in any case still doubtful, were big enough to be able to use flint 'implements' of the size associated with their remains.

CAUSES OF THE GREAT ICE AGE

After this brief account of the Great Ice Age, we may reasonably enquire, What were the probable causes that led to glacial conditions and made the creatures of the world shiver in the cold ? To be frank, we do not definitely know, though many theories have been advanced. Let us examine some of these.

Refrigeration due to Flattening of the Earth's Orbit

Firstly we might mention the view put forward by the astronomer Croll. He assigns the Great Ice Age to the inclination of the earth's axis combined with excessive flattening of the earth's orbit causing prolonged winters, and fast-fleeting summers when the temperature was neither sufficiently high nor of long enough duration to allow the snows to melt to any appreciable degree (see footnote p. 30). This theory has by now been generally abandoned, and it should be made clear that it has nothing to do with the time-scale of Milankovitch based on solar radiation into which the flattening of the orbit enters as one of the elements.

The more advanced reader is referred to the publications of Milankovitch and others.

Ice-Conditions due to Continental Uplift

A view that is now widely held assigns the lowering of temperature to uplift of large continental masses of the earth's crust, such as took place during the late Tertiary era and the Pleistocene. It was not likely that such colossal geological and geographical upheavals would fail to influence the world's climate. The result was that at higher elevations more snow fell, that snow fields were formed and glaciers developed, with concomitant lowering of the snow-line all round. Similarly, there is positive proof that during the Pleistocene, elevation of the Lower Himalayas took place. For example, about the middle of the Pleistocene, parts of the Himalayas were uplifted by not less than 7,000 ft., since we find that older rocks (of Lower Siwalik age) are shifted or thrust bodily over the younger, Middle Siwalik formations. And there is definite evidence that the Himalayas are still rising, for what appear to be Recent alluvial deposits have been seen thrust over the much older Siwalik rocks as, for example, in the Kalka area of the Punjab.

However, uplift alone cannot wholly account for glaciation because there are regions of the earth, like the high Tibetan plateau, which are not entirely covered by ice. Furthermore, the occurrence of Interglacial periods would imply that a reversal of geological and geographical events took place *at regular intervals*, bringing warmth, of which there is no evidence, although there is evidence enough of such negative movements, not only in Europe, but also in other parts of the world. In India, the presence of submerged forests along the coast of Bombay and in the delta of the Ganga and elsewhere may be regarded as evidence in point. Pleistocene climate saw many ups and downs and its behaviour has been rather similar to that of an automatic refrigerator. As soon as sufficient ice is formed the motor stops, only to restart before long. The "heavings of the earth's broad breast", causing uplift and subsidence of land, correspond to the regular throb of the motor, while the refrigerator itself might be the earth, on a small scale. Those who find it difficult to accept a frequent alternation of uplift and subsidence might

accept the basic idea that *uplift has increased the possibilities of ice-formation, whilst the Glacials and Interglacials are superimposed oscillations due to a different cause, such as seasonal distribution of radiation.* This appears to be at present the most probable explanation.

Ice Age due to Decrease in the Heat Radiated by the Sun

A third view assigns the Ice Age to a temporary decrease in the amount of heat radiated by the sun, which is known to vary slightly. Even an inconsiderable fall of the earth's temperature might so affect the northern latitudes as to cause extensive ice sheets to form. For further details reference may be made to pages 31-32, where the effects of solar radiation are discussed. However, the causes that probably led to variation in the solar radiation are still obscure.

The Earth catches a Chill

A fourth view envisages that the earth passed through an exceptionally cold part of space or through darkening clouds of matter which brought about a lowering of temperature and ice conditions. This is, however, a mere statement that the earth caught a chill in an unguarded moment—much like the physician's diagnosis when the malady is uncertain.

In short, of the four views expressed above, that of uplift causing a general lowering of temperature seems the most plausible. Other factors, of which unfortunately we have no clear knowledge, undoubtedly contributed towards this initial cause. We need not mention other theories; those described give an idea of the ways along which the causes of the Ice Age are being sought.

Other Ice Ages

In passing it may be mentioned that the Great Ice Age was not the only glaciation the earth experienced during the course of its long geological history, but there were several others, at different intervals. The Pleistocene or Great Ice Age gives the most spectacular evidence of its occurrence because of its proximity to us in time, and by virtue of its being the period during

which man has evolved, it has naturally received the greatest attention from scientists.

One period of glaciation occurred as long ago as the pre-Cambrian times during which no definite trace of organic life has been found, though stray evidence, such as the presence of worm-tracks, etc., points to its existence. It is a period of time so remote that none of the vertebrate groups—fishes, amphibians, reptiles or mammals—had even appeared, and it takes us considerably over 500 million years back.

Another glaciation occurred during the late Carboniferous and early Permian times, about 200 million years ago, and was even more widespread in the southern hemisphere, than that of the Pleistocene. Evidence of it, consisting of pebbles and boulders striated and polished by ice action, is found wellnigh the world over. In India a formation known as the Talchir Boulder bed contains numerous such boulders and pebbles, and may be seen in the coal-bearing areas of Bihar and in the Mirzapur district of Uttar Pradesh. A similar Boulder bed is seen in many parts of the Himalayas. This boulder bed of glacial origin is again seen in the Salt Range of the West Punjab (Pakistan), particularly in the neighbourhood of Khewra, the important salt-mining town, right on the Khewra-Choya Saidan Shah road.

INDIA: GLACIAL AREAS

Kashmir

The European Pleistocene, the first to be investigated in detail, naturally forms the basis of comparative studies within the continent of India and other regions of Asia.

As the problem of Palaeolithic man is closely connected with Pleistocene stratigraphy, we shall briefly deal with this, confining our attention to India, Pakistan and the contiguous regions of Burma and Ceylon. It may, however, be mentioned that the problems connected with early man in India and Pakistan are identical, despite new political boundaries.

In temperate Europe and in the Alps, the Pleistocene climatic alternations have been described as Glacial and Interglacial. However, in the Himalayan region where conditions were identical with those of the Alps, the climatic cycle (Glacials

PERIODS	DEPOSITS AND TERRACES (KASHMIR)	CLIMATIC PHASES : ARCHAEOLOGY	ALPINE EQUIVALENTS
POST-PLEISTOCENE	TERRACE 5 Deposition	NEOLITHIC, including Megalithic sites of Burzahom and Nunar PROTO-NEOLITHIC, pre-pottery stage of Sombur and Pampur	POST-PLEISTOCENE
UPPER PLEISTOCENE	TERRACE 4 Deposition	FOURTH GLACIAL	WÜRM
	TERRACE 3 Erosion	THIRD INTERGLACIAL	THIRD INTERGLACIAL
	TERRACE 2 Deposition	THIRD GLACIAL	RISS
MIDDLE PLEISTOCENE	TERRACE 1 Erosion UPPER KAREWA BEDS	SECOND INTERGLACIAL	SECOND OR GREAT INTERGLACIAL
	KAREWA GRAVELS	SECOND GLACIAL	MINDEL
LOWER PLEISTOCENE	LOWER KAREWA LAKE BEDS	FIRST INTERGLACIAL	FIRST INTERGLACIAL
	MALSHAHIBAGH CONGLOMERATE	FIRST GLACIAL	GÜNZ VILLAFRANCHIAN

Fig. 34. The Pleistocene sequence and terrace record in Kashmir. Note that the climatic phases—Glacial and Interglacial—correspond to those of the Alpine region. No authentic stone implements have been found in Kashmir earlier than the Proto-Neolithic. In the Proto-Neolithic, the climate begins with a comparatively cold phase, changing gradually into present-day conditions, which finally became established in Neolithic times. The above sequence obtains throughout the Himalayan region.

and Interglacials was also similar to that of the Alpine region, which enables us to establish fairly accurate correlation between those areas.

In India the upland vale of Kashmir, situated approximately 5,000 ft. above sea-level, was a lake during the Pleistocene Ice Age. Its remnants still persist as the Dal and the Wular into which the Jhelum now discharges its waters. In this Pleistocene lake were accumulated the wellknown Karewa deposits consisting mainly of clay, silt and gravel. The Karewas embody in their terraces and interbedded gravels and moraines the record of climatic fluctuations and of earth movements which uplifted this region more than once during the Pleistocene and brought about glaciation.

The sequence of climatic fluctuations during the Great Ice Age in Kashmir is summarised in Fig. 34 and is generally applicable to the Himalayan region. In this Table the correlation of the Kashmir glaciations with the Alpine sequence is obvious, the First, Second, Third and Fourth Glacials of Kashmir being equivalents respectively of the Günz, Mindel, Riss and Würm glaciations, while the First, Second and Third Interglacials correspond to similar climatic breaks in the Alps and parts of Europe. In the Alps, the Günz is preceded by several sub-stages. These were placed in the Pliocene by some authors, but on fossil evidence they are now assigned to the Villafranchian. In Kashmir the Pliocene consists mainly of freshwater sediments.

INDIA: PERIGLACIAL AREAS

The Narbada Valley

In the central peninsular region of India as, for example, the valley of the Narbada, the terrace record is far from clear. However, the available evidence appears to point to a parallel cycle of deposition and to similar stone industries as in the north-western (Potwar) region of the Indian continent where a complete sequence exists (p. 118). Whilst even the breaks (marked by uplift in the Himalayan, Narbada and Potwar regions) seem to occur at similar horizons, it must be stated that the correlation between the Pleistocene of the Narbada and the Potwar areas is based in addition upon the similarity of their stone implements.

But it has to be admitted that strict contemporaneity of these events has yet to be proved. What is important for the reader to understand is that in the Narbada valley, so remote from the Indus and Sohan[1] rivers, artefacts are found which typologically belong to the 'Sohan' Industry characteristic of the north-western part of the Indian continent, now in West Pakistan.

The sequence of events and the succession of stone industries in the Narbada valley is given in Fig. 35.

PERIODS	DEPOSITS AND THEIR EQUIVALENTS	SUB-DIVISIONS	ARCHAEOLOGY	
POST-PLEISTOCENE	COTTON SOIL GROUP =TERRACE 5	Cotton soil and silt. Basal gravels	Microliths (small flint and jasper blades and scrapers)	
PLEISTOCENE	UPPER GROUP =TERRACES 3 & 4	Pink clay Upper gravels	Rolled Acheulian hand-axes	Late Sohan flakes, cores and pebble-tools
	LOWER GROUP =TERRACES 1 & 2	Pink concretionary clay Basal conglomerates and gravels	Late Acheulian hand-axes and cleavers Abbevillio-Acheulian hand-axes and cleavers	Early Sohan flakes Pre-Sohan choppers
	LATERITE			

Fig. 35. The Pleistocene and Post-Pleistocene sequence of the Narbada valley. The terraces are not well-defined, but their probable equivalents are given above. The Laterite, indicating continental conditions, marks a long break at the close of Pliocene times. It was formed under a tropical climate, while Pluvial conditions seem to have set in subsequently. The upper stage of the Lower Group and the earlier stage of the Upper Group contain the well-known Narbada fauna consisting of *Equus namadicus*, *Bos namadicus* *Elephas namadicus*, *Bubalus palaeindicus*, *Cervus*, etc.

[1] Often erroneously spelt as Soan.

The Sabarmati Valley : Gujarat

During the last few years, valuable work has been done in this part of Gujarat by Sankalia, Iravati Karve and Kurulkar. More recently this has been extended by the researches of Zeuner, who has approached the problem from the geological standpoint. He has unravelled the geological and climatic succession of the Pleistocene of the Sabarmati valley which is summarised in Fig. 36, commencing with the *earliest* known phase, the Laterite.

GEOLOGICAL FORMATIONS	CLIMATES AND ARCHAEOLOGY
LATERITE	CLIMATE MORE DAMP THAN TODAY
MOTTLED CLAY	EARLIEST EVIDENCE OF THE SABARMATI IN ITS EXISTING BASIN.
CEMENTED GRAVELS	HEAVY RAINFALL PALAEOLITHIC MAN (FIRST APPEARANCE)
SILT PHASE	DRIER CLIMATE PALAEOLITHIC MAN PRESENT.
RED SOIL PHASE	CLIMATE HUMID PALAEOLITHIC MAN DISAPPEARS
MAIN DRY PHASE	CLIMATE DRY
DAMP PHASE	HUMID CONDITIONS
FOSSIL DUNES PHASE	DRY CONDITIONS REVIVED
SOIL APPEARS ON THE DUNES	MAN REAPPEARS AS MAKER OF MICROLITHIC TOOLS. NO POTTERY
LATEST DRY PHASE (due either to natural aridity or to deforestation by man)	POTTERY MAKING MAN PRESENT, POSSIBLY KNOWING AGRICULTURE
MODERN PHASE	LONG DRY SEASON, ALTERNATING WITH SMALL RAINFALL, AS AT PRESENT DAY

Fig. 36. Pleistocene sequence in the Sabarmati valley, Gujarat. Note alternation of wet and dry climates. Arid conditions set in finally. (Adapted from Zeuner).

From this sequence it is obvious that in Gujarat, too, wet and dry conditions alternated, with a tendency on the whole to a final setting-in of dry conditions.

Unfortunately, no extensive remains of vertebrate fossils have been found, nor is there other evidence on record which might enable one to correlate with precision the various phases noted above with the Himalayan Glacial periods, but the alternation

of humid and drier phases seems strongly suggestive of some parallelism. Moreover, the presence of Palaeolithic implements typologically similar to those of the Sohan industries of the West Punjab (Pakistan) and of middle to late Acheulian artefacts seems to indicate that Palaeolithic man in Gujarat lived during times corresponding to the Third Glacial period; his antiquity is thus estimated at between 150,000 and 200,000 years. But no actual fossil remains of Palaeolithic man have so far been found here.

The West Coast Region : Bombay

A Pleistocene succession has also been distinguished in the

PERIODS	DEPOSITS AND CLIMATE	IMPLEMENTS	STAGES
POST-PLEISTOCENE	SURFACE SOILS AND SANDS PRESENT-DAY CONDITIONS	Microliths	MICROLITHIC
PLEISTOCENE	UPPER CLAY INTERPLUVIAL	Blades and burins of angle and parrot-beak type.	AURIGNACIAN
	UPPER GRAVEL PLUVIAL	Blades and burins found on the Gravels. Fossils of the horse *Equus namadicus*, occur in the Gravels.	
	MIDDLE CLAY INTERPLUVIAL	Blades and scrapers found on the Clay. No implements in the Clay.	
	LOWER GRAVEL PLUVIAL Contains large boulders indicating pluvial conditions	Hand-axes and cleavers on the Gravels. Hand-axes etc. in the Gravels.	LATE ACHEULIAN ABBEVILLIO-CLACTONIAN
	LOWER CLAY NORMAL CONDITIONS	Choppers, cores, scrapers of crude type in the Clay, becoming very prolific upwards.	CLACTONIAN ? EARLY SOHAN INDUSTRY
TERTIARY	BASALT		

Fig. 37. The Pleistocene sequence near Kandivli (West coast region) Bombay. The alternation of Gravels and Clays indicates climatic fluctuations.

West Coast region of India. The ardent collector may reap a harvest of stone implements in the Padan Hill at Kandivli and around Borivli about two miles north of Kandivli where fossil remains of horse also occur, though somewhat sparingly.

Unfortunately this area has not been investigated in great detail and one can only await further researches for additional information. The Pleistocene succession at Padan Hill is shown in Fig. 37.

The East Coast Region : Madras

The Pleistocene of this region is fairly well defined, particularly in the coastal areas drained by the Kortalayar river. This river has cut through the Laterite and has developed four Pleistocene terraces, such as are seen in other parts of the Indian continent. These terraces contain a wealth of stone implements which is truly noteworthy. Most important from the archaeological

PERIOD	DEPOSITS AND TERRACES	ARCHAEOLOGY
POST-PLEISTOCENE	SURFACE DEPOSITS	MICROLITHS
PLEISTOCENE	TERRACE 3 Erosion	
	TERRACE 2 Deposition	Upper Acheulian hand-axes showing evidence of wood-technique, are found in Terraces 1-3.
	TERRACE 1 Erosion	
	DETRITAL LATERITE	Middle Acheulian hand-axes and flakes
	BOULDER CONGLOMERATE = Boulder Conglomerate Zone of Potwar.	Late series, with early Acheulian hand-axes Early series, containing Abbevillian hand-axes
PRE-TERTIARY GNEISS		

Fig. 38. The Pleistocene formations and terrace sequence at Vadamadurai, Madras coastal region. Scarcely any fossils have been found here, but stone tools are abundant. Terrace 4 also occurs but is not always clearly seen.

viewpoint are the localities Vadamadurai and Attirampakkam. The Pleistocene sequence at Vadamadurai shows the Boulder Conglomerate resting on a pre-Tertiary basement of gneiss, followed by Detrital Laterite and then by Terraces 1-3. Terrace 4 appears to be present but is not well-defined and is not considered here. The implements contained in these divisions belong to three different groups. The Boulder Conglomerate contains two series, an early, characterised by crude, rolled and heavily patinated hand-axes of Abbevillian type, and a late series of early Acheulian hand-axes with step-flaking. The Detrital Laterite contains middle Acheulian hand-axes which are flatter and have better defined step-flaking. This series also contains flakes with definite evidence of retouching. The third category characterises the Terraces 1-3 and contains, besides cleavers and discoidal cores, Upper Acheulian hand-axes which had evidently been prepared by the use of wood-technique. The stratigraphic and archaeological sequence is summarised in Fig. 38.

PAKISTAN

The Potwar Region

We have already unfolded the sequence of events during the Great Ice Age in the Himalayas and other parts of India. Let us now inquire into the geological and climatic conditions which obtained in West Pakistan, south of this great mountain chain, so that the reader knows of the environment under which primitive man lived there. It may be stated at the very outset that *most of this area, like the low-lying continental region of India, was never actually covered by ice even at the zenith of any of the four Glacials.*

Although in the remaining continental region of India, the Pleistocene has not been studied in the same detail as in the Potwar plateau, many workers believe that generally an identical sequence of climates obtained in both areas. Furthermore, whilst it is generally held that the Pluvials occurred over the whole world at the same time as the Glacial phases in temperate regions, recent work in the Sabarmati valley in Gujarat, leads one to the conclusion that this may not be strictly true of all regions, but only of the Mediterranean region lying north of the Dry Belt of the globe.

PERIODS	DEPOSITS AND TERRACES POTWAR REGION	FAUNA
POST-PLEISTOCENE	TERRACE 5 Deposition	MODERN FORMS
UPPER PLEISTOCENE	TERRACE 4 Deposition	Horse
	TERRACE 3 Erosion	Bison
	TERRACE 2 Deposition	Camel Wolf
MIDDLE PLEISTOCENE	TERRACE 1 Erosion	NARBADA FAUNA *Elephas namadicus* *Equus namadicus* *Bubalus palaeindicus* *Bos namadicus* *Hippopotamus etc.*
	BOULDER CONGLOMERATE Coarse gravels	
LOWER PLEISTOCENE	PINJAUR ZONE Silt, Sand and Clay	VILLAFRANCHIAN FAUNA *Equus,* *Elephas,* *Bos.*
	TATROT ZONE Sandstone, Conglomerate, Silt	
UPPER PLIOCENE	MIDDLE SIWALIK, DHOK PATHAN ZONE Sandstone	*HIPPARION* FAUNA

Fig. 39. The Pleistocene sequence in the Potwar region (West Pakistan) and its

CLIMATE	ARCHAEOLOGY	HIMALAYAN (KASHMIR) EQUIVALENTS
Present-day climate	NEOLITHIC	TERRACE 5 POST-GLACIAL
PLUVIAL Cool and Temperate	EVOLVED SOHAN (PINDI GHEB)	TERRACE 4 FOURTH GLACIAL
INTERPLUVIAL Warm and Temperate	LATE ACHEULIAN — LATE SOHAN-B	TERRACE 3 THIRD INTERGLACIAL
PLUVIAL Monsoonal Conditions ; Intermittent Dust Storms	LATE SOHAN-A	TERRACE 2 THIRD GLACIAL
INTERPLUVIAL Long Dry Period	ABBEVILLIO-ACHEULIAN (HAND-AXES) — EARLY-SOHAN (CHOPPERS AND CHOPPING-TOOLS)	TERRACE 1 SECOND INTERGLACIAL UPPER KAREWA BEDS
PLUVIAL Torrential Rainfall : Cool and Temperate	PRE-SOHAN CRUDE FLAKE INDUSTRY	SECOND GLACIAL KAREWA GRAVELS
INTERPLUVIAL Warm and Temperate		FIRST INTERGLACIAL LOWER KAREWA LAKE BEDS
PLUVIAL Cool and Temperate		FIRST GLACIAL MALSHAHIBAGH CONGLOMERATE
Subtropical		

correlation with the Himalayan Glacial cycle (After. Movius)

In so far as the Tropical Zone (Equatorial + Monsoonal Belts) is concerned, it is not absolutely certain that the respective Glacial-Pluvial and Interglacial-Interpluvial periods were contemporaneous. In any case, much more work needs to be done before one can arrive at final conclusions. But in order not to confuse the issue for the reader, we shall accept their contemporaneity pending further evidence in support of the other view.

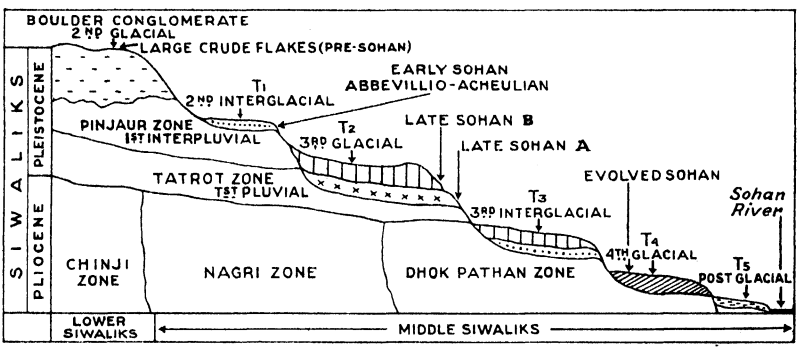


Fig. 40. Section across the Sohan valley showing terraces, geological formations and associated stone industries. Not to scale. (Based on Movius).

The Potwar region lying north of the Salt range, provides an excellent example of an area where, instead of glacial conditions, Pluvial and Interpluvial conditions prevailed (Fig. 39). The valleys of the Indus and Sohan rivers have been studied in detail by de Terra and Paterson, who have proved the existence of five successive terraces there, four of Pleistocene age and the fifth Post-Pleistocene (Fig. 40). Here too, the aggradation terraces connect up with moraines of the corresponding glaciations, proving an identical relationship between the terraces and moraines as in the Alps.

This region is of great importance not only from the point of view of climatic fluctuations during the Great Ice Age, but also in its bearing upon Palaeolithic and Neolithic man and his cultures. Here a close connection exists between the Pleistocene and underlying Pliocene rocks, together grouped in the Siwalik formation, which are deposits of freshwater origin about 20,000 ft. thick. This connection is naturally reflected in the climatic

changes from the Pliocene (Tertiary) to the Great Ice Age (Pleistocene), with which we shall now deal.

During the Pliocene, these deposits were being accumulated under tropical or subtropical conditions almost throughout its three substages, the Chinji, Nagri and Dhok Pathan which constitute the Lower, Middle and Upper Pliocene respectively (Fig. 40). It must, however, be mentioned that already in the Nagri stage (Middle Pliocene), drier conditions were setting in because we find abundant fossil remains of the Pliocene horse, *Hipparion*, indicating the existence of open grass plains instead of the forest growth of the tropics. This climatic change was continued into the Dhok Pathan stage which provides evidence of aridity. At the close of the Pliocene, the Potwar region was uplifted and this cycle of deposition, which began with the Upper Miocene, came to an end.

Considerable denudation took place as a result of the uplift, and a vast plain (peneplain)[1] came into existence. It was upon this plain that the first Pleistocene rocks (Tatrot and Pinjaur) were laid (see Fig. 40). The Tatrots consist mostly of deltaic deposits, conglomerates and silts, and contain the typical Villafranchian fauna of *Equus*, *Elephas* and *Bos* which, as we have seen (p. 103), characterises the commencement of the Great Ice Age and forms the boundary between the Tertiary and Pleistocene. Besides these, remains of *Camelus*, *Giraffa* and *Rhinoceros* also occur, particularly in the Pinjaurs.

The Tatrot fauna is on the whole sparse and seems already to indicate a change of climate. In addition, the presence of angular quartz grains indicates ice action, while the deltaic nature of these deposits—boulder beds, silts and massive freshwater sandstones—is evidence of heavy rainfall and of streams carrying large quantities of sediment. For these reasons, the Tatrot stage is considered as Pluvial and is equated to the First Glacial.

On the other hand, the presence in the Pinjaurs of the prolific fauna consisting of elephant, camel, rhinoceros, giraffe, no less the nature of the sediments, probably laid in vast plains by

[1]After a land area is uplifted, processes of denudation set in, and these, combined with river action, result in a level plain. This is known as a *peneplain*. Sluggish rivers are characteristic of mature peneplains where the processes of levelling have almost reached their ultimate limit. These rivers are then said to have reached their *base level of erosion*.

slow-moving rivers, appears to indicate exuberant forest growth and a warm climate, alternating with monsoons and dust-storms, rather similar to present-day conditions. For these reasons, the Pinjaur stage is regarded as an Interpluvial period, equivalent to the First Interglacial.

This was followed by further uplift which again brought about glaciation in the Himalayas. As a result, erosion occurred on a considerable scale in the mountain regions and the material was deposited in the lower regions as Boulder beds. The size and extent of the boulders indicate that the Himalayan rivers were then probably much more powerful than they are today. These (Pluvial) Boulder-beds constitute the Boulder Conglomerate stage and are of Second Glacial age, because they connect up with the moraines of this period in the Himalayas. *The Second Glacial period is important because, for the first time, the Himalayan glaciers appear to have reached the plains*, and glaciation was at its zenith.

The Boulder Conglomerate is no less important because *it contains the earliest evidence of man in the Indian continent in the form of crude stone implements*, grouped by de Terra under the 'Pre-Sohan' industry (Fig. 39).

The terrace record of this region begins with the Second Interpluvial period. Of the five terraces, the Second and Fourth have proved to be of glacifluvial origin, while the First and Third are Interpluvial or Interglacial. Now, if these terraces correspond to those of Europe and Kashmir, which the close similarity of the sequence strongly suggests, then the Second and Fourth Terraces correspond to the Second and Fourth glaciations, while Terraces 1 and 3 are identical with the Second and Third Interglacials respectively, Terrace 5 being Post-glacial, as elsewhere.

In Terrace 1 are found early Palaeolithic hand-axes of the Abbevillio-Acheulian type as well as choppers and chopping tools which typify the distinctive Sohan Industry. More evolved types of implements of this industry are found in Terrace 2 and Terrace 4.

The sequence in the Potwar region is summarised in Fig. 39. For comparison with its equivalents in Kashmir reference may be made to Fig. 34.

BURMA

The Irrawaddy Valley

A Pleistocene sequence parallel to that of Kashmir and the Potwar region obtains in Upper Burma. As in the Potwar area, the climatic phases can be described as Pluvial and Interpluvial (Fig. 42).

Commencing with the Pliocene, we have beds known as the Lower Irrawaddian containing the extinct Pliocene horse *Hipparion* and other fossils characteristic of the Dhok Pathan stage of the Potwar region. Following the deposition of these beds, there was an uplift, after which the Upper Irrawaddian beds were deposited. The Pleistocene commences with the Upper Irrawaddian which consists of river sands and silts and contains the typical Lower Pleistocene (Villafranchian) fauna composed of *Equus*, *Elephas*, *Bos* and other forms typical of the Upper Siwalik of

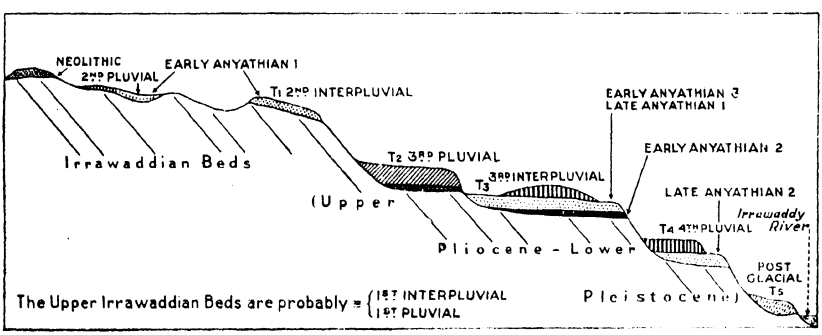


Fig. 41. Section across the Irrawaddy valley showing terraces, geological formation and associated stone industries. Not to scale. (After Movius).

India. The presence of the horse *Equus yunnanensis*, which is not known in India but which occurs in the Pleistocene of China, is accepted as proof that, in the Lower Pleistocene, Upper Burma was connected with South China. The Upper Irrawaddian covers, though somewhat doubtfully, the First Pluvial and First Interpluvial phases.

At the close of the Lower Pleistocene there was another period of uplift following which the Lateritic Gravels were deposited. This period corresponds to the Second Pluvial and is of prime importance. It was characterised by more severe monsoonal

conditions than even at the present day. According to Movius, the Irrawaddy was then a much bigger river than it is today. A fairly prolific fauna of elephants, rhinoceros, bisons, etc., then flourished.

Following this, the Pleistocene history of the region is deter-

PERIODS	DEPOSITS AND TERRACES (BURMA)	FAUNA
POST-PLEISTOCENE	TERRACE 5	MODERN FORMS
UPPER PLEISTOCENE	TERRACE 4 Deposition	FAUNA
	TERRACE 3 Erosion	
	TERRACE 2 Deposition	UNKNOWN
MIDDLE PLEISTOCENE	TERRACE 1 Erosion	MOGOK KARST FAUNA *Elephas namadicus*, *Stegodon*, *Rhinoceros*, *Aeluropus*, *Bos*, Pig. Deer and Porcupine
	LATERITE = Uru Boulder Conglomerate of N. Burma	
LOWER PLEISTOCENE (VILLAFRANCHIAN)	UPPER IRRAWADDIAN	VILLAFRANCHIAN FAUNA *Equus*, *Elephas*, *Bos*
PLIOCENE	LOWER IRRAWADDIAN	*HAPPARION* FAUNA OF MIDDLE SIWALIK TYPE

Fig. 41. The Pleistocene sequence and terrace record in the Irrawaddy valley,

mined from a study of the terraces, of which there are five as in other areas (Fig. 41). Of these, Terraces 1 and 3 correspond to the Second and Third Interpluvials and Terraces 2 and 4 to the Third and Fourth Pluvials, respectively. Terrace 5 is Post-Pleistocene and of Neolithic age, as elsewhere.

CLIMATE	ARCHAEOLOGY	HIMALAYAN (KASHMIR) EQUIVALENTS
PRESENT-DAY CLIMATE	NEOLITHIC	POST-GLACIAL
FOURTH PLUVIAL	LATE ANYATHIAN CULTURE	FOURTH GLACIAL
THIRD INTERPLUVIAL		THIRD INTERGLACIAL
THIRD PLUVIAL Rainfall 2 or 3 times that of the present times.		THIRD GLACIAL
SECOND INTERPLUVIAL Long dry period	EARLY ANYATHIAN CHOPPING-TOOL CULTURE	SECOND INTERGLACIAL
SECOND PLUVIAL Rainfall far heavier than at present.		SECOND GLACIAL
FIRST INTERPLUVIAL ?		FIRST INTERGLACIAL
FIRST PLUVIAL ?		FIRST GLACIAL

Burma, and Himalayan equivalents (After Movius).

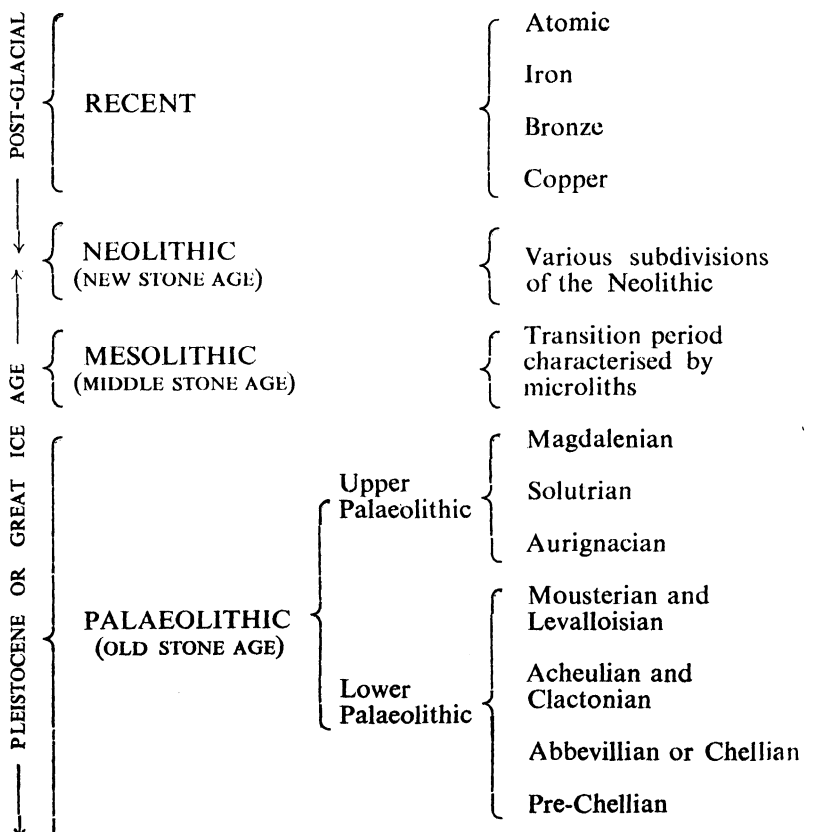
CEYLON

The Pleistocene of Ceylon and its records of river terraces have not yet been investigated in great detail. It has, accordingly, been thought desirable to deal with such evidence as is available when considering the Stone Age of this island (p. 166).

CHAPTER VII

THE STONE AGE AND LATER CULTURES OF EUROPE, INDIA, PAKISTAN AND BURMA

WHILE geologists have subdivided the Pleistocene into successive periods upon the basis of climatic fluctuations and vertebrate fossils, archaeologists have introduced cultural subdivisions, founded upon the typology or shape of stone implements manufactured by successive races of fossil men, as follows :—



1. The terms Abbevillian has now replaced the Chellian.

The major archaeological periods are further subdivided as shown in the right hand column of the Table on page 125. These smaller divisions are likewise based upon the typology of the implements. The Stone Age cultures lead gradually into the Metal Ages in a definite sequence, but it is not within our purview to deal with the latter in detail here. While these cultures appeared in the same order the world over, their relative antiquities and durations vary.

Some of these periods lasted many thousand years as may be seen from the following estimates which give, according to Zeuner, their durations in Europe before present times, i.e. counting backward from A.D. 1800.

Industry	Approximate earliest and latest dates	Duration in years
Crag industries	?—540,000	60,000
Abbevillian	540—480,000	60,000
Acheulian	430—130,000	300,000
Clactonian	540—240,000	300,000
Levallosian	250—70, 000	180,000
Mousterian	140—70, 000	70,000
Aurignacian	*c.* 100—50, 000	50,000
Solutrian	———	Short
Magdalenian	50-20,000 B.P.	30,000
Mesolithic	20—*c.*7,000	13,000

It is to be expected that the culture of the early human races—their ability to make stone implements, their sculpture and art, their psychology and customs—underwent noteworthy changes. On the whole, the cruder and rough hewn implements are found more in earlier than in successively later stages. This is but natural, for development in this direction kept pace with the progressive advancement or evolution of the human mind. However, advanced Stone Age cultures often overlapped the primitive, just as happens even today where primitive races that have scarcely overstepped the Stone Age, co-exist with people who pride themselves as belonging to the Atomic Age. It must be further emphasized that the durations of these periods were not uniform the world over. For example, the Metal Ages began in India much earlier than in Europe and we emerged from our crude Palaeolithic cultures much earlier than did the European Palaeolithic people. On the other hand, the

Megalithic culture of Europe preceded that of India by about two thousand years (see p. 155).

Cultural advancement continued in other directions also, for man who in the beginning could only *procure* food from nature learnt in due course to *produce* it by agriculture. This industry may have been learnt by man between 8,000 and 10,000 years ago, while the use of metals followed later, at least 5,000 years ago, if not in Europe, at least in other parts of the world. How long man took to achieve this may be appreciated by comparing the date when man first began to use metals with the probable total period of his existence on the earth—about a million years, at a liberal estimate.

An important fact which emerges from a study of the distribution of these implementiferous localities whether in Europe, India, Pakistan, Burma or Ceylon is that by far the largest number occur along river valleys or lakes, which naturally provided good hunting grounds, a plentiful supply of water and often material suitable for the manufacture of implements. The only other considerations that weighed with primitive man in selecting sites for habitation were protection against weather and security. Observe how many prehistoric sites were located in caves or other inaccessible places. Neolithic man in Ceylon, for example, even had raised 'look-out' rocks on the platforms projecting in front of the caves whence an approaching enemy could be detected and dealt with.

THE STONE AGE OF EUROPE

As in the case of the problem of glaciation, the archaeological subdivisions of the Stone Age were founded and first studied in detail in Europe. We shall accordingly review these briefly in order to facilitate such correlations and comparisons as are possible with other parts of the world.

Stone implements are first met with in the Pre-Chellian. As might be expected, these implements are of uncouth design, even though they bear unmistakable marks of workmanship. From such implements as these were developed the hand-axes or *coups-de-poing* of the Abbevillan or Chellian period, and are characteristic of it. They vary a great deal in shape while preserving certain common features.

The Acheulian marks a further improvement in the hand-axe, which was now thin, of oval shape and carefully retouched along the edges. Another type of rather specialised implement found in the Acheulian is the Levallois type of flake, which is typically rather thin and broad and retouched by neat flaking.

Throughout the Pre-Chellian and Abbevillian times, the climate in Europe remained warm, changing only slightly at the commencement of Acheulian times. Man could, therefore, live in comfort in the open, either on or near the river terraces. With the advent of the Mousterian period cold began to set in and *for the first time man sought the caves for shelter.*

Mousterian implements are, somewhat unexpectedly, not so finely developed as some of the earlier ones, and smaller rather than larger forms are characteristic of the period. The Abbevillio-Acheulian hand-axes have become less important while scrapers and borers etc., have taken their place. A noteworthy feature of the small Mousterian flints is that they are worked on one side only. It is difficult to say whether a wooden handle was employed in the use of any of the Mousterian implements, but it would not be at all surprising if this was the case.

Human vanity dates back to very ancient times and we have definite evidence that the Mousterians, probably both men and women, were accustomed to adorn themselves with shells and other natural objects. Indeed in Europe the Mousterian period appears to mark the first use of ornaments. The early Mousterians followed the practice of burying their dead. While some of the dead were buried in the sleeping posture, others appear to have been tightly bundled up, being tied with stems of creepers or lianes (Fig. 115). Some of the implements then in use were buried along with the dead. There is reason to believe that the Mousterians practised magic and some may have been cannibals, but one cannot be too certain on these points. The early Palaeolithic races appear generally to have led a wandering life.

The close of the Mousterian period marks the end of the early Palaeolithic. Let us then follow the fortunes of the successors of the Mousterians—the men of the late Palaeolithic Age.

There is unmistakable evidence that progress in the gradual refinement of the stone implements was maintained, for in the Aurignacian we find smaller implements which are narrow, pointed and finely worked. This is, however, not to say that the

coups-de-poing disappeared completely. These are found intermittently in almost all the later stages. *Here also appeared for the first time authentic worked bone implements* along with the flints. Many of the flint and bone implements were no doubt fitted with handles, the exact nature of which is not known, though it is proved that they were made of wood. In Aurignacian times were also developed fine implements shaped like arrow-heads, known as *Shoulder points*. The Aurignacian implements were beautifully retouched along the edges.

In the succeeding stage, the Solutrian, the implements attain their highest development, being retouched all over. In the earlier part of this period, however, some of the implements e.g. the *Solutrian leaf points*, were retouched only on one side, the other side being untouched and flat. Of particular interest are the *Laurel leaf points* which were worked on both sides.

The latest phase of the Palaeolithic, the Magdalenian, is characterised by implements made mostly of bone and horn. These are variously ornamented and may be described as javelins, harpoons, etc. At the same time, a great many of the beautifully shaped smaller implements known as microliths also began to appear.

The Magdalenians were fine artists and certainly far excelled the artistic abilities of the modern primitive tribes. There is much force and dynamic expression in their figures of hunters and the hunted. They frequently used ornaments made of ivory, shell, bone and even mineral crystals. Drawings depicting dance scenes are known and it is not improbable that the dances were accompanied by rhythmic sounds. One of the best examples of this is the drawings in the caves at Cogul in Spain. Similar paintings (though not of like antiquity) have been found in India and will be referred to presently. It is, however, not likely that the drawings and paintings in the caves were meant for decoration. They were probably of a ceremonial nature, for invariably these occur in remote parts of the caves where, naturally, they cannot be easily seen. The Magdalenians were also good sculptors. It is interesting to note that *in the late Palaeolithic are found, for the first time, engravings and models of animals in relief.*

Both in the Aurignacian and Magdalenian times (as also in the early Palaeolithic) the dead were often buried in a flexed

posture suggesting that the bodies were tightly bundled up. This mode of burial is practised even today among the primitive races of Australia, Southern Africa and America. Among these people the belief is that the dead are thus literally bundled off, body and soul, never more to return to worry their survivors.

Before the late Palaeolithic was succeeded by the Neolithic, a stage known as the Mesolithic or Middle Stone Age intervened. During the Mesolithic, small geometric flints or microliths predominated (Greek, *micros* = small; *lithos* = stone, i.e. small stone implements). There was also an abundance of painted pebbles. Some of the paintings bear close resemblance to the hieroglyphs of Egypt, but no definite relationship is implied. These are distributed in parts of Africa, Spain and France. The African Microlithic (Mesolithic) industry is known by the name of Capsian and extends over Europe and parts of Asia including the Indian continent. The Mesolithic industries of these regions, therefore, belong to the same culture complex.

Finally we come to the Neolithic or New Stone Age when, for the first time, we find the people possessing a knowledge of agriculture; when cattle and horses were domesticated and when men knew the use of pottery and the art of polishing stone implements. The typical artefact of this period is the polished stone axe. Europe received its Neolithic arts via Africa. Where exactly agriculture was first practised is not definitely known, but it may have been in Egypt or India. While men of the late Palaeolithic and Neolithic ages were good artists they do not seem to have had any clear idea about composition, and figures are frequently seen to be drawn haphazardly. Among the colours with which they were familiar are various shades of red and yellow (both presumably derived from ochres), white, which is rare, and violet and grey. It is not unlikely that proper brushes were used for making some of the paintings.

The Neolithic merges into the Copper Age, followed in succession by the Bronze, Iron, and lastly by the most formidable, the Atomic Age.

THE PALAEOLITHIC AGE IN INDIA, PAKISTAN, AND BURMA

The foregoing summary of the Stone Age industries of Europe was given in order to enable us to understand more clearly the

corresponding industries of the Indian continent, Burma and Ceylon[1], with which we shall now deal. Their distribution is shown in the large map at the end of this volume.

The credit for discovering the first stone implement on this continent goes to the Geological Survey of India. The first palaeolith picked up at Pallavaram near Madras by Bruce Foote (1863) has been followed by a host of new finds in the Indian States of the Punjab, Uttar Pradesh, Vindhya Pradesh, Madhya Bharat, Bihar, Orissa, Bombay, Madras and other parts of peninsular India. The Palaeolithic industries of Southern India are grouped under the term Madrasian.

In Pakistan various stone industries are represented in the West Punjab, Sind and Baluchistan, those of the Palaeolithic of the north-western region being known as the 'Sohan' or 'Pre-Sohan', according to age.

Similarly, the Burmese finds are referred to a special culture known as the Anyathian. Tools of this culture occur extensively along the Irrawaddy valley in Upper Burma, as for example, near the oil-field town of Yenangyaung, at Kyauk, Nyaungu near Pagan and sparingly in the Mandalay area, e.g. Pakokku and Minbu. Strangely enough, in spite of two American expeditions, and the author's own explorations between 1929 and 1935, no stone implements have so far been found in the hinterland of the Northern or Southern Shan States of Burma. Here probably lies a virgin field of discovery, for the searches already carried out may not have been exhaustive enough.

In Ceylon, both the Palaeolithic (Ratnapura) and Neolithic (Balangoda) industries are fairly extensively distributed, particularly in the south (Sabaragamuva province), while a number of sites have also yielded microliths. It is important to record that some Palaeolithic implements from the lower Ratnapura levels resemble those of the Sohan, rather than the Madrasian, types.

In all the four regions referred to above, artefacts occur which date back almost to the earliest Palaeolithic. Thus, hand-axes of early Palaeolithic times are recorded from parts of Madras, Bombay, Madhya Bharat, Uttar Pradesh etc., in India; from the Potwar region of Pakistan, from the Irrawaddy valley in Upper Burma (hand-adzes) and from Ratnapura, Southern Ceylon.

[1] The Stone Age of Ceylon will be dealt with in detail in the next chapter.

It is important to note that the Palaeolithic stone cultures found in the Potwar area of Pakistan and in Burma are different from the standard Indo-European types. It is for this reason that they have received the distinctive names, the 'Sohan' in Pakistan and the 'Anyathian' in Burma. The Anyathian artefacts of Burma resemble those of China, so that in the Lower Palaeolithic period and even later, the Burmese culture complex resembled the Eastern (Chinese) rather than Western (Indo-European) type. This was probably because direct connection between India and Burma came to an end after the Lower Pleistocene and is supported by the fact that the later, Middle Pleistocene, faunas are different in the two regions.

Taking the Palaeolithic as a whole, a complete picture of the period in the Indian continent, Burma or Ceylon cannot yet be given, and, what is more unfortunate, *we have no knowledge of the men who shaped these artefacts, for no authentic fossil remains of theirs have yet been found.* We shall thus have to content ourselves with an account of the implements left by them and to draw such conclusions as are possible.

INDIA

The Madras Hand-Axe Industry

In the chapter on the Great Ice Age reference has already been made to several occurrences of Palaeolithic artefacts in India. We shall here deal in detail only with the more important of these finds.

Of prime interest and importance is the Madras region. In some localities as, for example, Vadamadurai and Attirampakkam in the valley of the Kortalayar river, implements are so common that they can be picked up literally in cartloads. At Vadamadurai, three separate groups of implements belonging to successive ages can be distinguished. These are derived from the Boulder Conglomerate, Laterite, and Terraces 1-3, respectively, in ascending chronological order (see Fig. 38).

The earliest group contains two types. Firstly, there are the crude hand-axes of Abbevillian type without much trace of retouching, and the irregularly shaped cores. These are the oldest known artefacts of the Madras Industry. They are distinguished by a heavy *patina* or external weathered surface.

Secondly, there are the less-patinated early Acheulian types. These are more advanced than the Abbevillian types, being

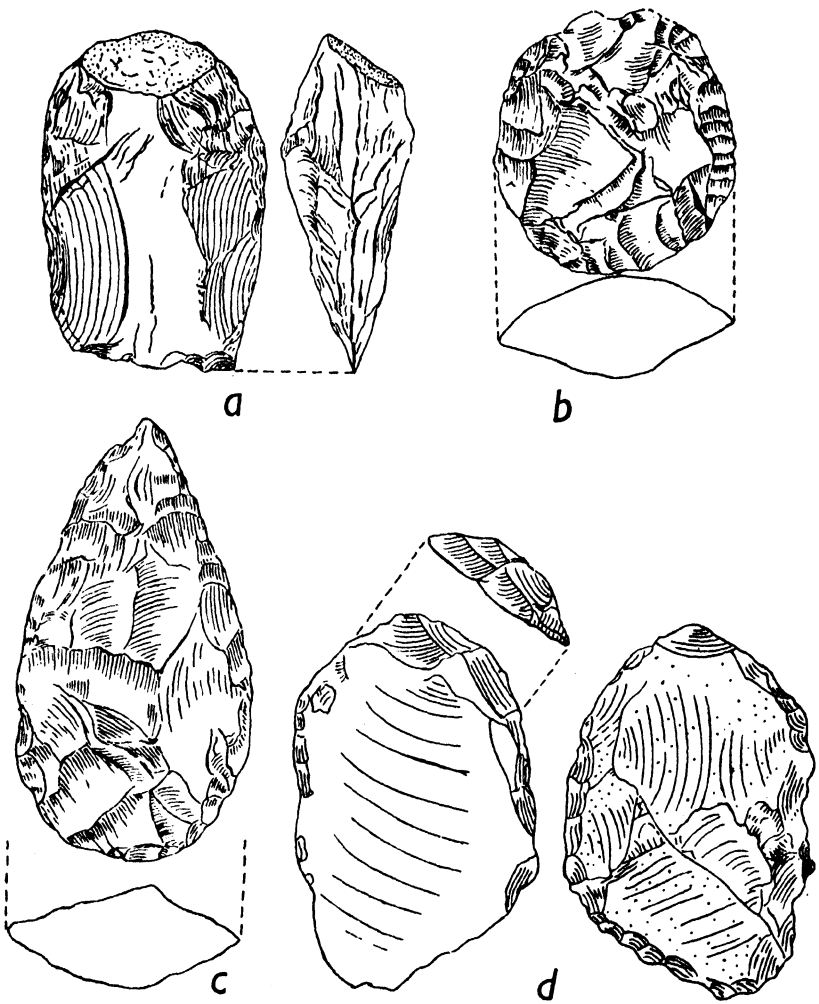


Fig. 43. Palaeoliths of the Madrasian industry from Attirampakkam.
a, cleaver with parallelogrammic cross-section (Pneil or Vaal technique of South Africa); *b*, disc with Acheulian technique; *c*, Madrasian hand-axe of Acheulian type; *d*, scraper based on a flake; note faceted striking platform and margin trimmed by secondary flaking (Levallois technique). (After Krishnaswami)

more regular in shape, and *show the first evidence of step flaking*. The cores, too, are better formed.

The middle group contains hand-axes of middle Acheulian type. They are more advanced than the early Acheulian types referred to above, for they are flatter and show better-defined step flaking.

The upper group includes less-patinated hand-axes of upper Acheulian type, discoidal cores and cleavers. There is evidence to prove that *at this stage the wood technique was introduced for the first time* in the preparation of cores. This means that whereas hitherto Palaeolithic man employed a stone hammer for flaking, he now also used a wooden mallet, which naturally produced finer work because strokes could be better controlled.

At Attirampakkam are found late Acheulian implements. They are of interest as they show the Vaal or Pneil technique of South Africa (Fig. 43*a*). Such hand-axes are oval in outline, sharp-edged and with a single scar on the lower surface. The upper surface is regularly flaked. Various implements from this locality are shown in Fig. 43.

PAKISTAN

Palaeolithic Industries of the Sohan and Indus Valleys

Western Pakistan was the seat of the distinctive Palaeolithic industry known as the 'Sohan', after the river of that name. These artefacts occur in the valleys of the Sohan and the Indus rivers, in the latter case between their confluence and the ancient town of Attock. Typically they consist of pebble-tools, with which are associated flake-tools. They were invariably shaped out of quartzite or trap pebbles, not flint, and are classified as *Pre-Sohan*, *Early Sohan* and *Late Sohan*.

The earliest known of these implements have been referred to the Pre-Sohan Industry by de Terra. They consist of massive, crudely shaped, much-worn flakes, based on pebbles (Fig. 44). They belong to the Second Glacial Period and were contemporaneous with the formation of the Boulder Conglomerate (Figs. 39 & 40). Implements of Pre-Sohan type have also been found as far east as Jammu (Kashmir).

Following the Pre-Sohan of the Second Glacial are the early Sohan choppers and Abbevillio-Acheulian hand-axes of the Second Interglacial period. They are found in the deposits of

Terrace 1. Their Second Interglacial age is suggested by their much-worn condition. They were manufactured during the Second Interglacial and subsequently became deposited in the gravels overlying Terrace 1.

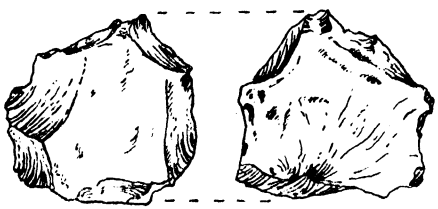


Fig. 44. Pre-Sohan quartzite implement from the West Punjab, Pakistan. Two aspects of a massive, crudely worked and rolled flake from the Boulder Conglomerate at Kallar. This is one of the earliest implements found in the Indian continent and, therefore, represents the first record of man's existence on the continent. (After de Terra and Paterson).

Three different categories have been recognised among the early Sohan artefacts, depending upon the extent of patination and rolling suffered by them. But it has not been possible to assign them to distinct stratigraphical horizons even though they show progressive advance from comparatively crude to more refined types.

The early Sohan tools were shaped out of flat, oval or rounded quartzite pebbles (Fig. 45). They were mostly used as choppers or scrapers and were obviously 'hand-implements', that is, not meant for hafting. These tools have been described as flat-based or rounded pebble-tools and had their cutting edge on one side only. Some pebbles were, however, flaked on both sides and represent the most advanced types. In addition, this industry is characterised by flakes and cores. On the whole, these types resemble implements of the early Clacton Industry of Europe (see p. 125), which is characterised by flake implements obtained by striking a stone or core against a fixed stone anvil. Their characteristic feature is that their striking platforms do not show signs of preparation.

Following the early Sohan comes the late Sohan Industry with a wider distribution than the former. The tools, still based on pebbles, now show comparatively fine workmanship (Fig. 46). Two phases of this industry have been recognised. The earlier, Phase A, consists of small, finely-worked pebble-tools,

together with flakes and cores. Some flake-tools exhibit the Levallois technique (Fig. 46*b*). They belong to the Third Glacial period and occur in the Basal gravels of Terrace 2. In

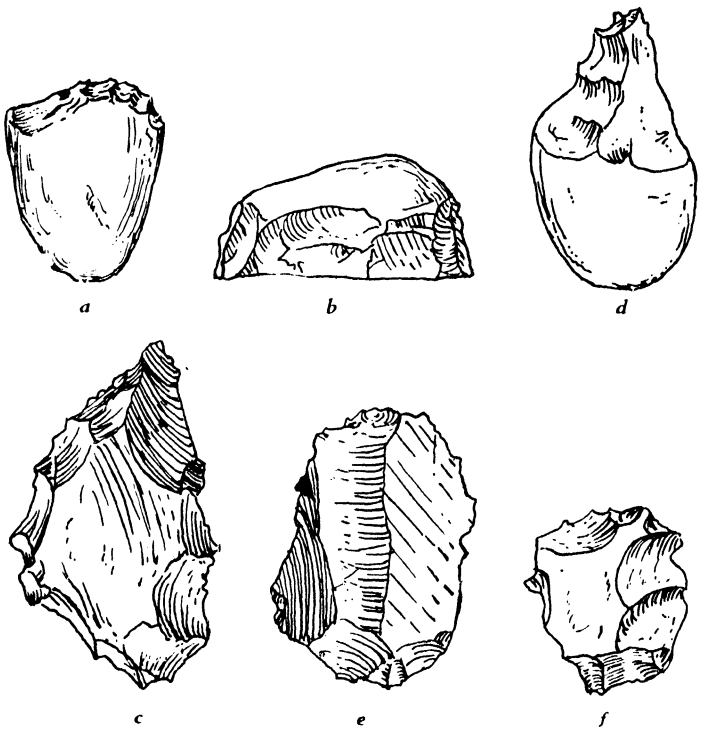


Fig. 45. Early Sohan (Lower Palaeolithic) choppers, chopping tools, flakes and cores, from the West Punjab, Pakistan.
a-c, more or less flat-based pebble tools. *a*, with a somewhat convex and steep cutting edge; *b*, with a straight cutting edge; *c*, with a pointed cutting edge; *d*, rounded pebble tool. All these had one cutting edge only. (Rounded pebble tools were made by removing flakes from an entire pebble, not from a prepared flat surface); *e*, flake showing primary flaking only, reminiscent of the 'Clacton' industry; *f*, a more or less discoidal core from which flakes were detached all round. (After de Terra and Paterson)

Phase B, though pebble- and core-tools are present, flakes and blades predominate. The latter resemble the late Levalloisian types of Europe.

The Potwar region of Pakistan is of particular interest in that two different industries, the Sohan (characterised by choppers and chopping tools) and the Abbevillio-Acheulian (characterised by

hand-axes of the Madras type), flourished side by side. In later stages there was an overlap of the two industries for we find

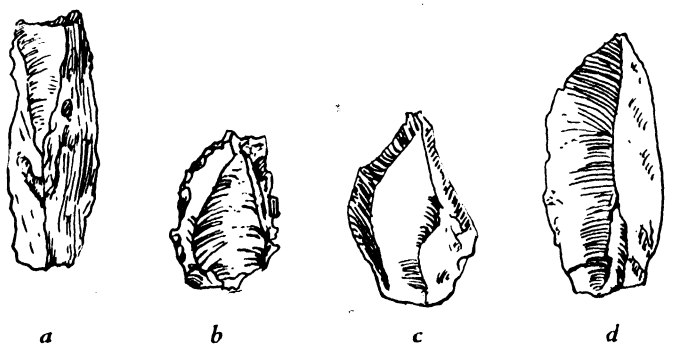


Fig. 46. Late Sohan (Lower Palaeolithic) implements from the West Punjab, Pakistan.
a, elongated, parallel-sided flake—a true blade; *b*, a flake implement with a distinctly Levallois type of flaking; both of late Sohan-A stage. (Simpler flakes showing 'Clacton' technique are also found along with Levalloisian types); *c*, and *d*, implements from Sohan-B stage. (After de Terra & Paterson)

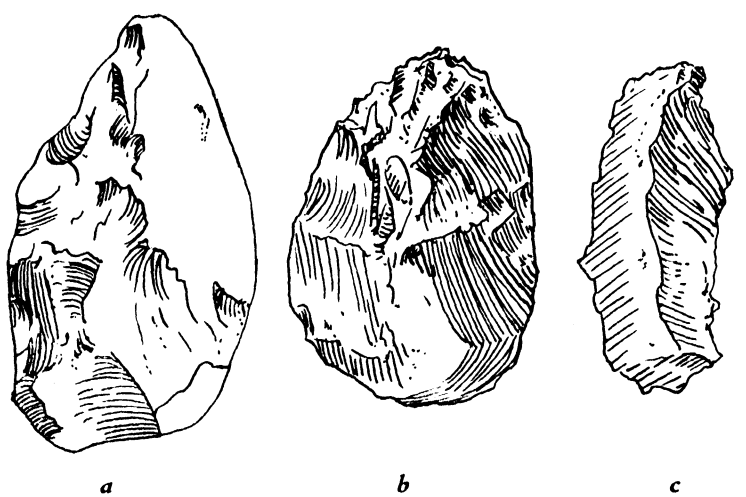


Fig. 47. Abbevillio-Acheulian (Lower Palaeolithic) implements from Chauntra, West Punjab, Pakistan.
a, cordate, unworn hand-axe; *b*, another hand-axe; *c*, blade. (After de Terra and Paterson)

both Sohan and Acheulian tools occurring together at the well-known locality of Chauntra. From this locality, Abbevillian,

middle Acheulian and late Acheulian forms have been recorded. This admixture, however, did not take place till the Third Interglacial. It is equally noteworthy that hand-axes have been found only in the Sohan, not in the Indus valley. Figure 47 illustrates two unworn specimens of late Acheulian age from Chauntra. These belong to the youngest of the above series. Another characteristic form is a blade found associated with these specimens, while cores and flakes also occur.

In Pakistan too, as in other parts of the Indian continent, not a single Palaeolithic fossil human bone has been discovered and we are completely in the dark as to the men who shaped these tools. Nor have we any idea as to the manner in which the authors of these two divergent industries differed from each other.

Before we leave this subject, attention may be drawn to other meeting grounds of the Sohan (pebble-tool) and Madras (hand-axe) Industries. These are the basin of the Rihand in Uttar Pradesh, Mayurbhanj in Orissa, the Sabarmati valley in Gujarat, Bombay; and even the far southern region of Madras. It is apparent that although the centre of origin of the Sohan industry lay in the north-west of the continent, it was far flung in its distribution, though naturally of lesser importance in the outlying regions.

BURMA

The Anyathian Culture

The Palaeolithic culture of Upper Burma has been named the Anyathian by Movius (Burmese, *ān-ya-thā* = an Upper Burman). An important point to note is that *the hand-axe, which is so characteristic of the Madras Industry, is completely absent from the Anyathian culture.* Its place is taken by the hand-adzes to which further reference will be made presently. The lower division of the Anyathian covers the Lower and Middle Palaeolithic while the late Anyathian spans the Upper Palaeolithic. Reference has already been made to the localities where these industries have been found. These occur chiefly along the left bank of the Irrawaddy (see Figs. 49 & 50).

Palaeolithic man in Burma used two kinds of pebbles for making his implements, namely, fossil wood and silicified tuff. As the name indicates, fossil wood is nothing but tree stems

replaced by silica (as a rule), while tuff is a rock consisting mainly of volcanic ash. Rare instances of the use of quartzite pebbles for this purpose are, however, known. Three different types of

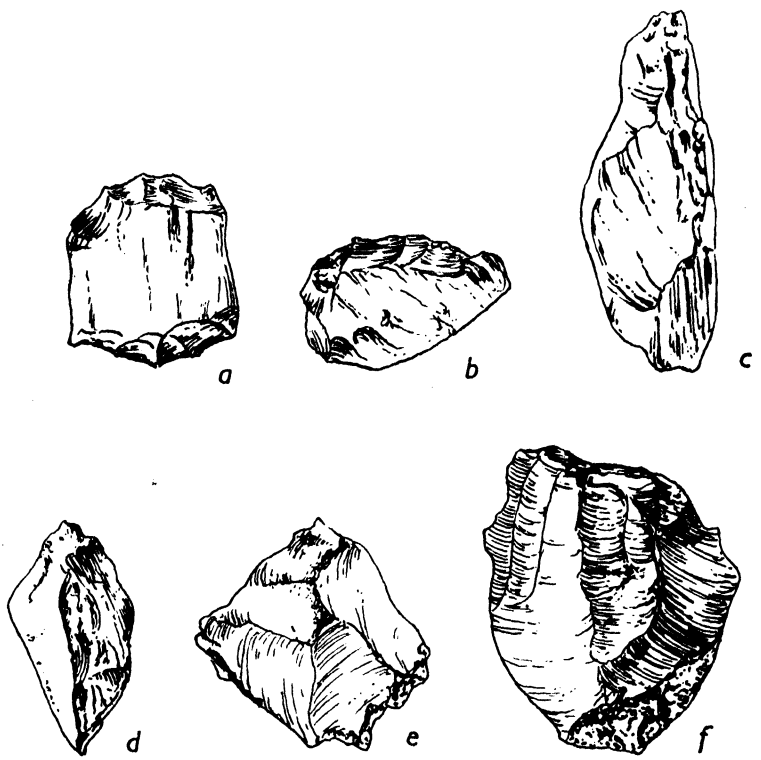


Fig. 48. Early Anyathian (Lower Palaeolithic) implements from Burma, made of fossil wood and silicified tuff.

a, hand-adze with two working ends; *b*, true side scraper; *c*, side view of a triangular scraper showing attempts at secondary working as proved by the rounded edges ; (*a-c*, made of fossil wood) ; *d*, side view of another chopper; *e*, chopper with an alternately flaked edge, a type characteristic of the early Anyathian; *f*, core produced by removal of flakes from one face of a pebble. (*d-f*, made of silicified tuff). Blades, points and perforators are generally absent in the early Anyathian. (After Movius)

stone implements occur in the early Anyathian, namely, hand-adzes, choppers and chopping tools (Fig. 48). The adzes, which were more or less rectangular, were most characteristic of the industry. They were based on cores and *their cutting or chopping edges were at right angles to the major axes of the implements.*

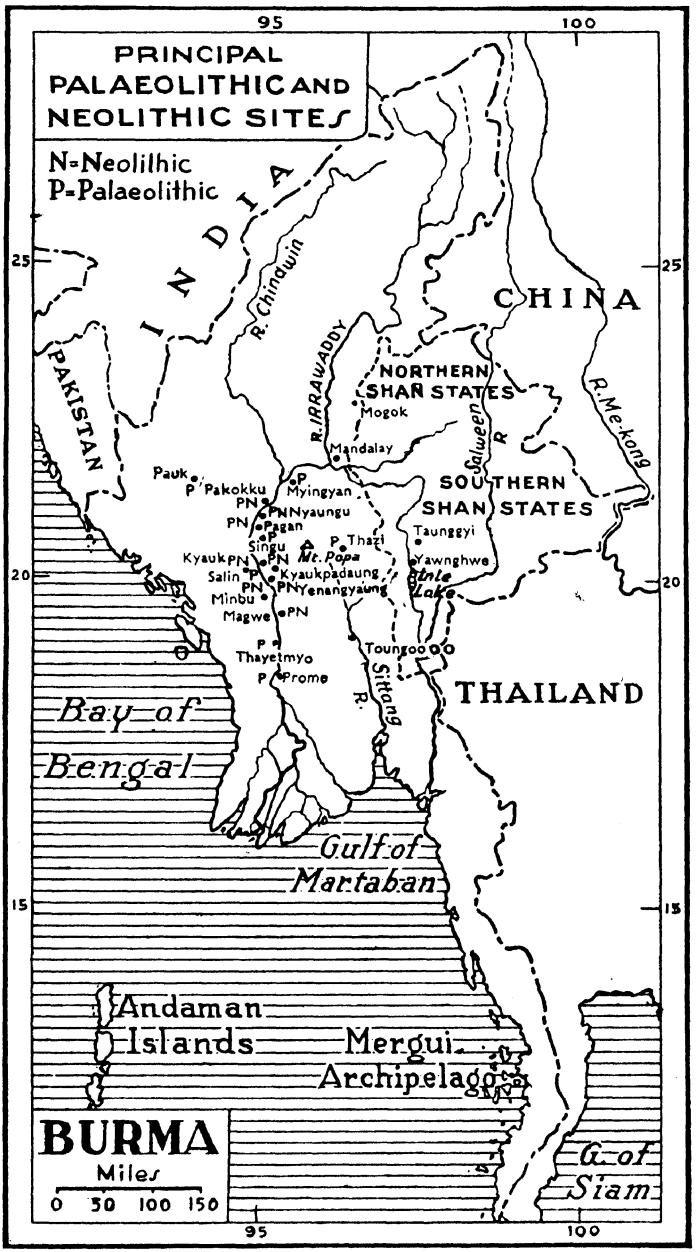


Fig. 49. Illustrating Palaeolithic (Anyathian) and Neolithic sites.

They were worked only on one side. In this respect they differed from the hand-axes which were worked on both sides and are, therefore, known as *bifacial.*

The chopper was an implement of comparatively large size with a straight cutting edge and was worked only on the upper surface. The chopping tools consisted of cores derived from pebbles by flaking.

PRINCIPAL PALAEOLITHIC AND NEOLITHIC SITES OF BURMA

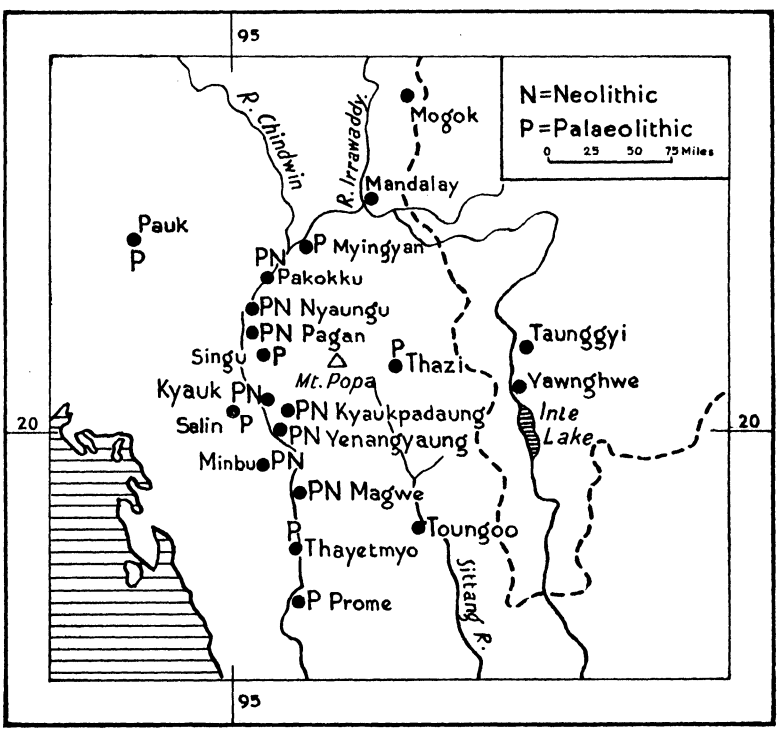


Fig. 50. Portion of Fig. 49 enlarged, showing archaeological sites.

These were the characteristic tools of the early Anyathian. They range through the Second Pluvial, Second Interpluvial and Third Pluvial periods. The late Anyathian implements (which are not figured here) were similar to those from the early Anyathian and were developed directly from the latter but were better formed. The distribution of the Palaeolithic industries in

Burma is shown in the accompanying map (Fig. 49). Figure 50 shows these localities on a larger scale map.

THE MESOLITHIC OR MIDDLE STONE AGE

In some ways the Mesolithic or Middle Stone Age of India and Pakistan is even less known than the Palaeolithic, while little light has been thrown upon this period in Burma. One difficulty is that microliths are sometimes also found in the late Palaeolithic and even in the Neolithic period, so that in the absence of other evidence one cannot always be certain as to their exact horizon. Indeed, there is little doubt that the manufacture and use of microliths has persisted into present times, for some of the modern aboriginal races make these out of splintered glass derived from beer bottles left by their more 'civilised' contemporaries !

While Palaeolithic implements were usually made of flint, quartzite or basalt, microliths were shaped from less common siliceous materials such as agate, carnelian, jasper, quartz or other forms of silica. They were shaped into points, crescents, triangles, blades, and also include small cores and beads. Another difference between Palaeolithic tools and microliths is that the former were, as a rule, used singly, whether hafted or unhafted, whereas the microliths appear to have been mounted on a handle in series to form a cutting edge. It is, however, known that some of the microliths were mounted singly on a handle for specific purposes.

Microliths are distributed widely in India and Pakistan and also occur in Ceylon (see large map at end of volume). In India they have been found in Kashmir (Pampur and Sambur), Bihar (Seraikela), Tinnevelly district (Sawyerpuram), Gujarat (Hirpura, Langhnaj, Valasna), Bombay (Kandivli), Madhya Pradesh (Singhanpur, Hoshangabad, Pachmari,), the Narbada valley and several other places. More recently Sahni (M.R.) and Ahmad found a prolific locality near Kota in the Mirzapur district of Uttar Pradesh, which has yielded various types of microliths and some beads.

In Pakistan, microliths occur in the Peshawar district (Jamalgarhi), Karachi district (near Karachi) and in Shahpur district.

As already pointed out, the Mesolithic industry of the Indo-Pakistan region closely resembles that of the Mediterranean region which is known as the Capsian industry. It is even possible that the microlithic industries of the Mediterranean and Indo-Pakistan regions were the products of people belonging to one and the same racial type, for recent work in Gujarat has shown that the fossil man discovered there by Sankalia and Iravati Karve possessed Hamitic or Negroid affinities. It appears, therefore, that there was an influx of north-east Africans or Proto-Egyptians into India during the Mesolithic times.

Nothing is known of the Mesolithic period in Burma.

Implements resembling the Indian Mesolithic types occur in the Balangoda Culture phase of Ceylon and will be dealt with in the chapter on the prehistory of this island.

INDIA

Gujarat, Mysore and Bellary

Although there are numerous sites in India where Mesolithic industries flourished, we shall briefly refer to only a few of these occurrences. These are the Sabarmati valley in Gujarat, Brahmagiri in Mysore and Sanganakallu in Bellary. The

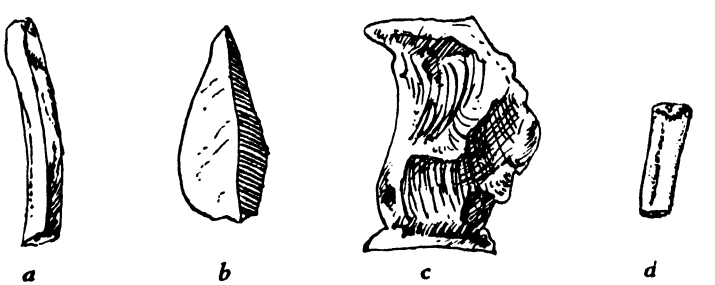


Fig. 51. Microlithic stone implements from Gujarat, Western India.
a, narrow curved blade; *b*, point; *c*, *naga* or cobra-hooded borer; *d*, long perforated bead; all from Langhnaj. (After Sankalia and Karve).

Sabarmati valley is important because it has yielded not only valuable microlithic material at Langhnaj, (Figs. 51*a-d*), Hirpura, Valasna and Akhaj but because fossil remains of man (Fig. 63), including complete skeletons, were unearthed at Langhnaj. These skeletons appear to represent deliberate burials

and are associated with microliths, bone tools and other objects. Their state of fossilisation and comparisons with microlithic phases elsewhere suggest a higher antiquity than some are inclined to assign to them. According to Karve and Kurulkar, "Palaeolithic man was separated from the Microlithic man by nearly 40 feet or more of loess and reddish silt", which might represent a large time interval. However, more work remains to be done before any precise opinion can be expressed, for the types of tools found do not suggest the true Mesolithic, but a younger age.

The Brahmagiri site is of interest from another viewpoint for there was a contemporaneous development of both Microlithic and Neolithic cultures and, before the former disappeared, a Megalithic people knowing the use of iron came upon the scene.

Numerous microliths occur at Sanganakallu in Bellary and have been described by Subarao.

PAKISTAN

The Proto-Neolithic

The Proto-Neolithic of Sind constitutes a special phase of the Mesolithic, distinct from the Microlithic as normally understood. In it probably lay the roots of the Harappa and Mohenjodaro stone industries, forerunners perhaps of the Indus Valley civilisation.

The distinctive tools of this phase were long, slender blades and cores, from which (latter) the blades were flaked off. The cores bear a striking resemblance to the fluted cores from the surface deposits at Sanganakallu (see Fig. 53*i*). Such implements are found near Sukhur and Rohri. It is worthy of note that similar types of cores and blades are found as far south as Raichur in Hyderabad State (see map at the end of this volume). This occurrence, so remote from the Sukhur-Rohri-Khairpur area without any intervening link, is indeed a puzzle to archaeologists. The Proto-Neolithic is also represented at Pampur and Sombur a few miles from Srinagar, Kashmir. In addition to the known localities, the author discovered a factory site on the flat-topped hills to the east of Khairpur in Sind. The Kirthar limestone forming these hills contains large flint nodules upon which the industry was based. The presence of a

wide and extensive cave, open at both ends, and another shorter one, makes this locality most significant. The cave, situated in the cliff-face of the hill, occurs within a short distance of where the factory site was found. Unfortunately, the cave itself could not be explored at the time of the author's visit, but such evidence as exists suggests that it might have been inhabited by man in Neolithic or earlier times. Careful examination of this cave and the surrounding region is likely to yield important results and is strongly advised in view of the fact that so few caves in the Indian continent have been explored with any degree of thoroughness or have produced bone remains of man.

Some authorities are of the view that these Proto-Neolithic industries are of fairly recent date. The presence of cores and blades at Mohenjodaro similar to those of Sukhur and the Khairpur areas lends credence to this view.

THE NEOLITHIC OR NEW STONE AGE

The passage of the Mesolithic or Proto-Neolithic cultures into the Neolithic has not yet been satisfactorily defined in India. Indeed, as will be apparent from the brief account of the various cultures given, these cultures often overlap and exact delimitation of cultural horizons is not always feasible.

The distinctive character of the Neolithic or New Stone Age is that its type implement, the stone axe, usually made of basalt, was invariably polished. Neither Palaeolithic nor Mesolithic man knew the art of polishing stone implements. The Neolithic implements may be variously described as celts or axes (in which the cutting edge is in line with the handle), adzes (with the cutting edge at right angles to the handle), hammer-stones, fabricators, picks, chisels, etc.

INDIA

Neolithic implements occur widely in India as, for example, in Kashmir (Burzahom and Nunar), in Uttar Pradesh (Allahabad and Banda districts), Vindhya Pradesh (Panna district), Bihar (Patna, Ranchi and Singhbhum districts), Assam (Garo and Naga Hills), Hyderabad and Mysore States (Brahmagiri), and in many parts of Madras, particularly Bellary. (See map at the end of the volume).

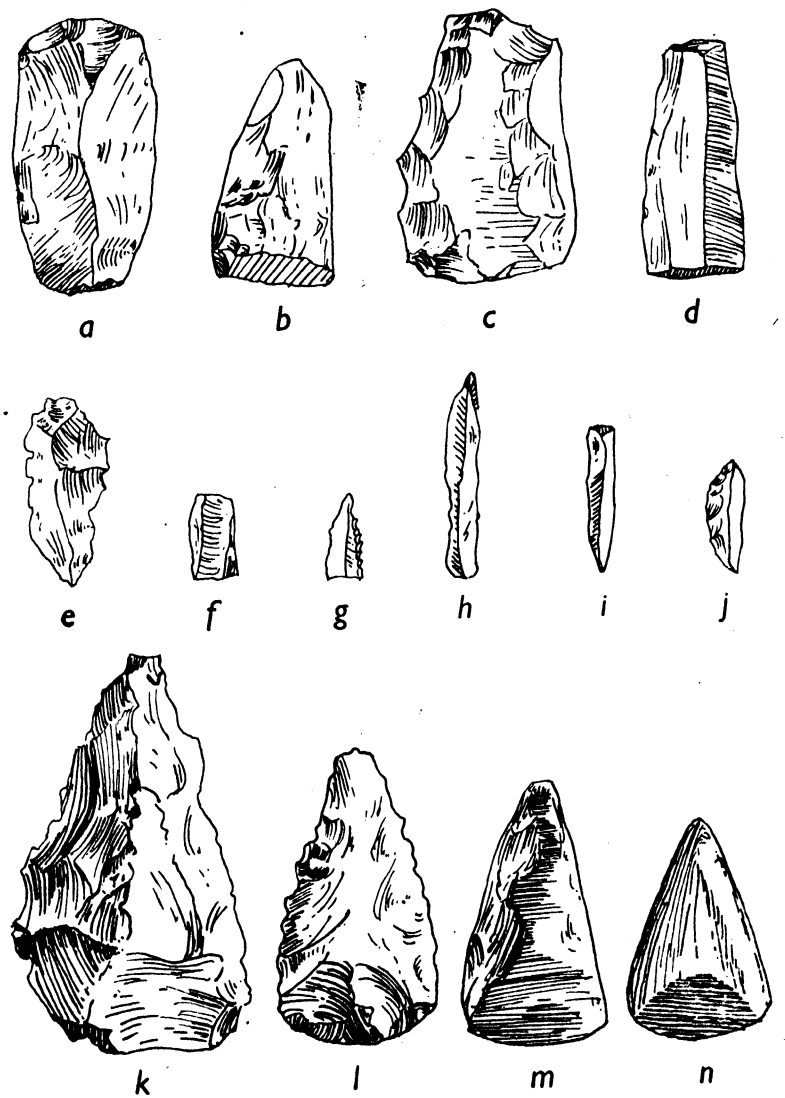


Fig. 52. Neolithic implements from Bellary, Madras;
a-c, various types of axes; *d*, chisel; *e-j*, various types of microliths; *k-n*, celts at different stages of manufacture (After Subarao),

Of the above occurrences those from Burzahom and Nunar in Kashmir, Brahmagiri in Mysore, and Bellary in Madras are important and have been studied in greater detail than some others. Recent investigations at Brahmagiri by Krishna prove that in this region the Neolithic culture persisted right up to the early historic period, though elsewhere in India the Metal Ages—Copper, Bronze and Iron—had already appeared in succession.

Excavations at Sanganakallu, Bellary, by Subarao have revealed an almost parallel development of Neolithic industries to those found at Brahmagiri. At Sanganakallu the youngest culture was of the Megalithic type. The Megalithic culture of this locality was preceded by a Neolithic phase yielding a great variety of stone axes at all stages of manufacture (Fig. 52). Lower still in the sequence were found heavily patinated flakes and other implements together with microliths, which were also associated with the true Neolithic polished-axe industry. At one place, the polished stone axes occur so profusely and at so many different stages of manufacture that Subarao claims this to be a factory site.

Some implements were attached to handles, presumably with fibre, or were fitted directly into them. One difference between these and the modern hammer is that, while in the latter case the handle is fitted *into* the hammer-head, the Neolithic hammer-head (axe) was fitted into a hole of suitable size *in the handle*. Obviously even Neolithic man had not found means to drill a hole right through the axe to accommodate a handle, though this would, in any case, have been a source of weakness even in a weapon made of basalt or quartzite.

In order to give some idea of the ingenuity of Neolithic man, we shall briefly describe some of his tools, how he made them, and how he used them.

The polished axes were made in three or four stages (Figs. 52 *k-n*). Firstly, a trap boulder of suitable size was selected and was reduced to a roughly triangular shape by bold flaking. At this stage the axe possessed a rough cutting edge and high ridges. These ridges were next removed, and at the same time the cutting edge was improved. The third step was to grind the axe, removing all irregularities. Lastly, the axe was polished. This was ingeniously done in parallel grooves carved out in hard rock. Such grooves, about eight inches in length and

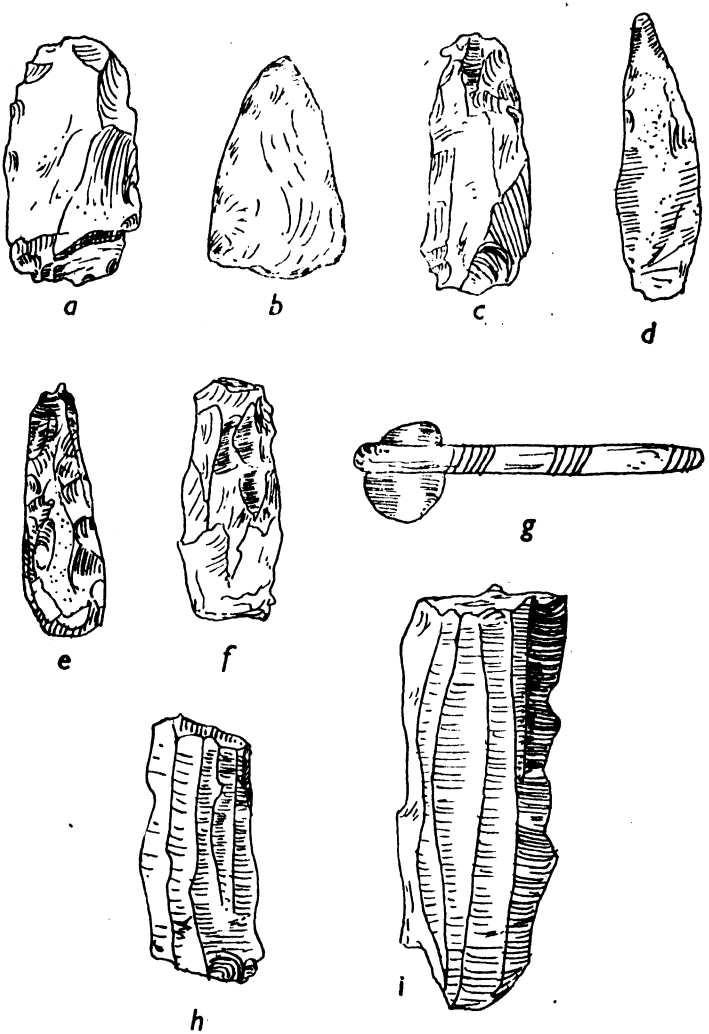


Fig. 53. Neolithic implements from Bellary, Madras.
a-c, various types of axes. (After Subarao) ; *d*, chisel; *e*, pick; *f*, fabricator; *g*, hammer-stone. (After Thomson and Brown) ; *h* and *i*, fluted short-blade cores, from the Nagaldinne area and from the surface deposits at Sanganakallu, respectively (After Subarao).

approximately an inch and a half deep, are found on North Hill within the confines of Bellary town itself. The axe was pressed into the groove and moved to and fro, which gave it a high polish.

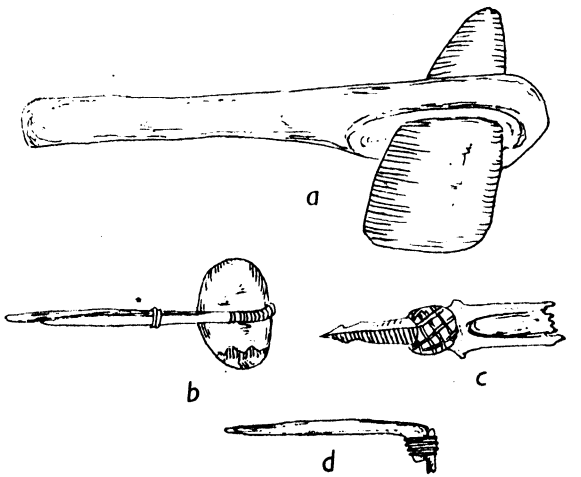


Fig. 54. Methods of hafting used by Neolithic man.
a, hafting of 'club-head' type; *b*, 'bent-withy' type; used for grooved axes ; *c*, 'spear-head' type ; *d*, adze tied to handle with cutting edge at right angles to the axis of the handle. (After Foote, Coghlan and De Morgan).

The fabricator (Fig. 53 *f*) was a small, crude tool and was used in the later stages for removing irregularities in the axe. Hammer-stones were rounded or oval pebbles with a constriction at one end for hafting (Fig. 53 *g*). They were used for striking blows in the process of manufacture of the tools. Adzes were axes with sharp cutting-edges and were probably used for chopping wood. Other tools are also illustrated in Fig. 53.

The tools were hafted in various ways, some of which are shown in Fig. 54.

PAKISTAN

In Pakistan, Neolithic implements have been found at Shadipur in the Attock district of the North-West Frontier Province and at other localities. But our knowledge concerning these is yet imperfect and their exact horizons have not so far been precisely defined.

BURMA

Stone implements were first discovered in Burma as long ago as 1894 by Noetling who assigned to them an Upper Miocene to Lower Pliocene age because of their apparent association with certain datable vertebrate fossils. This find naturally evoked great interest because it implied the somewhat revolutionary view for the time, that man with a high order of

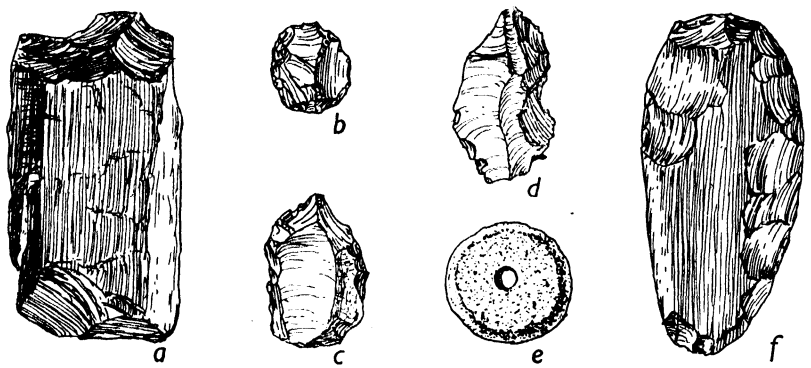


Fig. 55. Neolithic stone implements from Burma; *a*, typical hand-adze made of fossil wood, and *b*, small scraper, from Kyauk; *c*, double side-scraper and perforator, from Pagan; *d*, perforator, from Minbu; *e*, polished spindle-whorl made of metamorphosed slaty rock, and *f*, polished celt, from Magwe (After Movius).

intelligence existed during the Tertiary epoch. Further examination, however, soon showed that these implements had been disturbed from their place of origin, and that originally they occurred on the surface and were subsequently redeposited, becoming associated somehow with beds of late Tertiary age. Still later, these Burma implements were regarded as Palaeolithic and it was not till quite recently that their Neolithic age was established because of the find of polished stone axes and potsherds in the implement assemblages.

Whilst the type locality of the Neolithic lies near milestone 39.2, Kyaukpadaung-Popaywa road, implements of this age have been found near Magwe, Minbu, Yenangyaung, Kyauk, Pagan, Nyaungu, Pakokku and other localities (see Figs. 49 and 50). The implements found at many of these localities are made of silicified tuff or of fossil wood. Though of Neolithic age, these

implements are rather like those from the Palaeolithic (late Anyathian) mainly because they are made of fossil wood which lends itself only to limited treatment, being workable only across the grain of the wood. Since they are more recent than the Anyathian implements, they are either fresh-looking or only lightly patinated. In addition to these, there are the polished

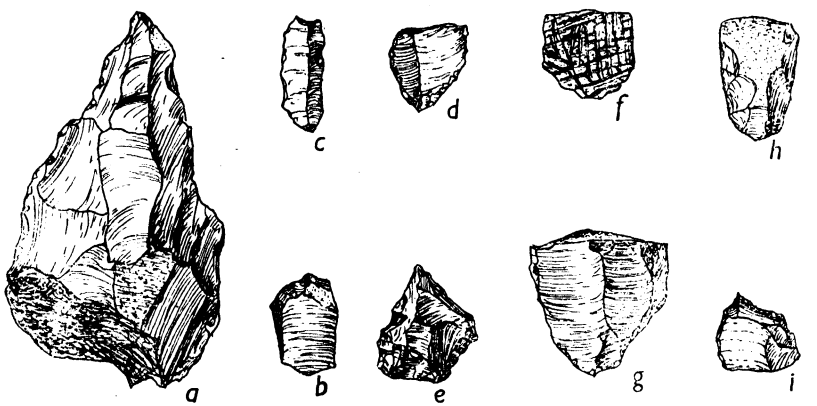


Fig. 56. Neolithic stone implements and a potsherd from near Kyaukpadaung, Burma;
a, large, crudely flaked pick; *b*, small end-scraper made on a flake; *c*, small blade; *d* and *e*, two other examples of end-scrapers; *f*, a typical mat- or cord-marked potsherd; *g*, typical example of small core; *h*, small ground and polished celt made on slaty rock; *i*, roughly triangular shaped borer (After Movius).

stone implements of basalt and schist. The main difference between the Palaeolithic (Anyathian) implements and those of the Neolithic is that the Palaeolithic tools were generally of large size, because they were based on cores, while the Neolithic ones were small for they consisted mostly of flakes and blades.

Near Kyaukpadaung, the following geological section is exposed, according to de Terra, in descending order :—

1 Topsoil containing artefacts
2 Brown volcanic ash
3 Grey tuff containing beds of silicified ash
4 Mudflow deposit
5 Tilted Upper Irrawaddian beds

The Neolithic implements occur in the topmost layer and also in the alluvium of the valley carved through the above sequence. They consist of crude scrapers of large size, choppers, picks and a single polished stone celt. These are associated with matt- or cord-marked potsherds. The presence of the polished stone celt establishes their age as Neolithic. Similarly, stone axes and potsherds have been found at Magwe and elsewhere (Fig. 56). Indeed the association of polished celts and matt- or cord-marked pottery is widespread in the Neolithic of S-E. Asia, having been also found in Indo-China and Malaya.

It is important to record here that the Burmese type of polished stone axe (Fig. 57) is met with in Assam and as far west as Chota Nagpur. Similar celts are recorded in Southern India as far south as the basin of the Godavari. It seems obvious that this culture spread in this direction along the eastern coastal region of India, but the cultural wave was probably not persistent. This, nevertheless, indicates that connection had been established between the two regions during the Neolithic, although, as we have already seen, this was non-existent in early Palaeolithic times.

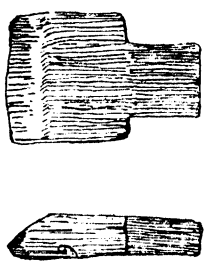


Fig. 57. Burmese of Neolithic shouldered celt found in the Singbhum district. (After De Morgan).

No stone implements or other handicraft of man has so far been discovered in the Shan States region of Upper Burma. However, remains of edible shells and what appear to be fragments of Neolithic pottery occur in certain caves as, for example, those near Mong Pawn, Yawnghwe and Tongta. This has been taken as evidence that man existed at least on the Southern Shan plateau during Neolithic times and he may have occupied the region even earlier, during the Mesolithic. But the complete absence of stone implements makes any positive assertion on this point impossible.

THE PROTOHISTORIC PERIOD

The Neolithic cultures merge almost insensibly into the Proto-Historic. By this time agriculture and domestication of animals had established themselves and man had acquired a community

sense. He had thus begun to live in small villages and to build up family life on a more secure basis. Evidence of these acquisitions appears to exist in the north-western part of Pakistan, where small settlements are known to occur. To this category belong the cultures of Shahi Tump and Kulli in Southern Baluchistan, which probably date back about 4,000 years. Gradually, as people became more prosperous and began to attach importance to ownership of property, they built large urban settlements and cities. To the latter part of this period belong the well-known ruined cities of Mohenjodaro and Harappa, both in Pakistan, and others near Ropar in Ambala district and Rangpur in the Limbdi district of Saurashtra, India. They all belong to a culture known as the Indus Valley Civilisation, which extended as far west as Sumer in Mesopotamia.

It is unnecessary in a work of this nature to give details of individual discoveries at Mohenjodaro, Harappa, etc. We shall, therefore, deal very briefly with the Indus Valley Civilisation and its people as a whole. This civilisation takes us back 4,500 years and appears to have attained its zenith in the second half of the third millenium B.C. The use of stone implements such as long blades was still extant.

In regard to this great cultural heritage, Wheeler significantly remarks that "the Indus Valley civilisation was politically and socially in advance of the king-ridden or priest-ridden societies of the West, and had precociously reached a phase of comparatively quiescent democracy, a bourgeois economy, devoid of what may be conveniently called citadel rule. The relative scarcity of military equipment supported this inference."

Several human skeletons have been found at Mohenjodaro. Normally the people of the Indus Valley Civilisation practised burial. Racially they belonged to living dolicocephalic types. The author has geological evidence which strongly suggests that, beside Mohenjodaro, many cities on the Indus might have been devastated by floods. This evidence consists of the alluvium of the Indus left high and dry on a hillock known as Budh Takkar, much above the present river-bed. This alluvium could not but have been deposited by exceptional floods on the Indus when the river rose high, submerging the surrounding country for miles. Moreover, the floods must have lasted over a long period to enable alluvium several feet thick to be deposited on

Budh Takkar—and to cause a glorious cultural episode to come to a sudden end !

THE VEDIC AND EPIC AGES

Following the Proto-Historic period we enter what is in some respects the most important episode in the annals of Indian culture, the period of the *Vedas* and of the great epics, the *Ramayana* and *Mahabharata*. And yet considering its importance to us we know but little about it. This period spans the interval between the Mohenjodaro-Harappa culture and Alexander's invasion of India in 324 B.C. From the archaeological standpoint, the period has been called the Dark Age though culturally it might well be termed the Golden Age of India, for during this era we had attained our zenith in so far as philosophy and literature were concerned. Our knowledge concerning the science and fine arts of this period is, however, still obscure.

There appears to be evidence in certain of the burial sites at Harappa which suggests that these might belong to the earliest period of Aryan influx into this land. According to Lal, this period corresponds to the second quarter of the second millenium B.C. "to which might also belong the Jhukar and Jhangar cultures of Sind, which successively followed the Harappa culture".

While no precise opinion can be expressed, it is surmised that the copper hoards consisting of swords, harpoons, celts, human figures etc., found in parts of India belong to this period. Here may be included the swords found at Fategarh, celts and harpoon of Bithur (Kanpur district) celts and harpoon from Rajpur, a human figure and harpoon from Bisauli, all in Uttar Pradesh; the axes and bar-celts from Palamau and Ranchi in Bihar and the large hoard of metal tools etc., from Gungeria in Madhya Pradesh. According to Lal, these implements represent a period prior to the introduction of iron and "though not proved, these implements were associated with a phase of the Aryan expansion from the land of Seven Rivers (modern Punjab and environs) to the Gangetic Plains."

MEGALITHIC SITES

We shall now deal with another culture-complex which is unique in many respects—the Megalithic, characterised by megaliths. These, it may be explained, are monuments where rituals

were held or which constituted burial sites. They were invariably built of large stones, whence the name. (Greek *megas*=large, *lithos* = stone). The monuments are variously shaped. Those at Brahmagiri take the form of elaborate burial structures, others consist of four massive stone pillars capped by a large slab and are locally distinguished as *Topikal*, that is, cap-shaped (Fig. 58). Still others have been named *cists*, *dolmens*, *cairns* and *barrows*.

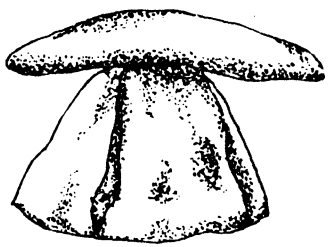


Fig. 58. A Megalithic monument of the *Topikal* type found in Cochin State. (After Lal)

Megaliths have been found at Burzahom and Nunar in Kashmir; at Khera near Fathepur Sikri, Deodhoora in Almora district, Uttar Pradesh, as well as in the states of Bombay, Orissa, Rajasthan and Madhya Bharat. Though megaliths occur as far north as Leh in Ladakh, this culture appears to have held sway mainly in Southern India. Actual fossil remains of man have been found at one South Indian locality named Aditanallur, and will be described in due course along with such other human fossil remains as have been discovered in the Indian continent. It should, however, be mentioned that no actual megaliths occur at Aditanallur, and the reference of the locality to this period is based upon its general cultural associations. The available evidence appears to suggest that the Megalithic culture flourished between the latter part of the first millenium B.C. and the end of the first century A.D. This evidence consists mainly of associated coins of the pre-Christian era and of pottery characteristic of the first century A.D. It is remarkable that although the Indian megaliths bear a close resemblance to those of Europe, the latter are chronologically much earlier and are assigned to the period between 2,500 B.C. and 1,500 B.C. The reason for the marked similarity between the Indian and European megaliths, separated by such a long time-interval, is not easy to explain.

THE HISTORIC PERIOD

The study of historic man is beyond the scope of this work. The pageant of human evolution, physical and cultural, that

we have just witnessed will, we hope, enable the reader to understand how far and in what direction man has progressed in his mental and physical qualities. His familiarity with his own environment, culture, and scientific achievements, will also enable the reader to express a verdict whether, viewing the picture as a whole, man has progressed or retrogressed during the last two thousand years, that is, during the span of historic times.

ROCK PAINTINGS AND SCULPTURE

In addition to the stone implements referred to above, there are various rock paintings and engravings in different parts of India, which prove the presence of early man on this continent. But comparatively little systematic study has been made, and

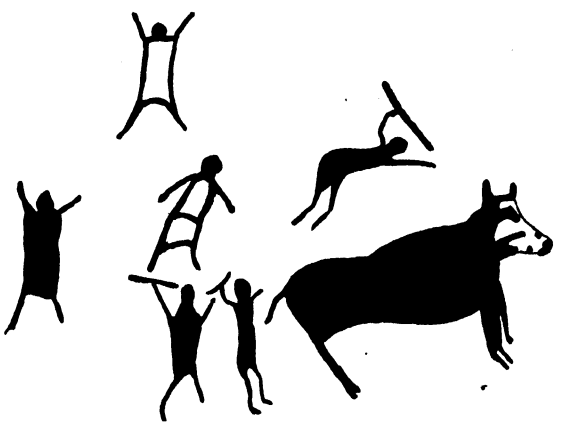


Fig. 59. Rock painting from Singhanpur in the Raigarh district of Madhya Pradesh, India, representing a hunting scene.

it has to be confessed that, in spite of various attempts, our knowledge of the subject leaves much to be desired. An intensive campaign is needed to elucidate and interpret this aspect of the evidence of man's handiwork in India.

Of the more important centres of rock paintings we would mention the Sone Valley in Mirzapur district, and Manikpur in Banda district, both in Uttar Pradesh, while of equal interest are the localities of Singhanpur in Raighar district, and Hoshangabad and Pachmari in the Mahadeo Hills, all in Madhya

Pradesh. Of considerable interest are the coloured paintings of rhinoceros, bison and various hunting scenes in the caves at Vijayagarh in Mirzapur district. Of these animals, the rhinoceros is now almost extinct in India and survives only in parts of Assam. Some have presumed, though without sufficient justification, that these paintings belong to the late Palaeolithic times. Similarly, the paintings at Singhanpur in Raighar district have also been sometimes accepted as of late Palaeolithic age (Fig. 59). However none of these paintings can be regarded as truly

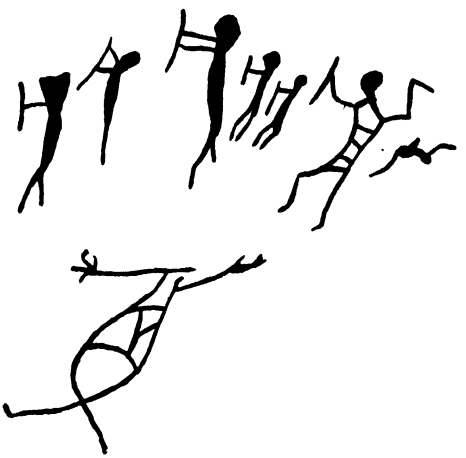


Fig. 60 Another painting in the Singhanpur rock shelter, occurring below that depicted in Fig. 59. This also represents a hunting scene.

prehistoric. Incidentally it may be mentioned that they resemble paintings in the caves at Cogul in Spain, though the two are not of like antiquity. The rock engravings at Ghatsila in Bihar, appear to have an Australian impress and may indicate points of contact between the two continents (Fig. 61).

More recently, the figure of an animal resembling a giraffe, now extinct in India, has been recorded by Misra from the rock shelters at Hoshangabad, in Madhya Pradesh. These shelters are believed to date from the Neolithic or New Stone Age, and if this interpretation is correct, it would indicate that men of the New Stone Age in India were probably familiar with the giraffe. There is, however, no record here of fossil giraffes later than the Lower Pleistocene and the view expressed above has yet to be authenticated by actual fossil finds. Until then, this curious picture

remains something of a puzzle. Microliths have been found in some of the caves in Madhya Pradesh, and the associated paintings might well belong to that period. However, this cannot be authentically proved since the use of microliths has persisted to much later times.

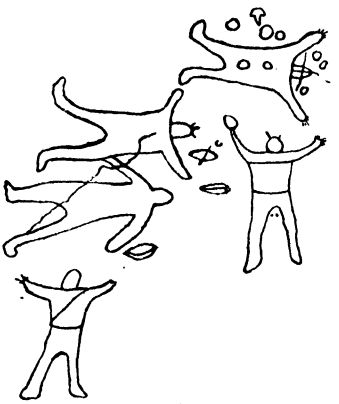


Fig. 61. Hunting scene carved in rock near Ghatsila, Bihar. This resembles certain Australian carvings and is probably of Neolithic age.

Of the Indian caves with more recent paintings we might mention the Ekdal cave in Bellary. These paintings are believed to be of Neolithic age.

Certain drawings on erratic boulders lying near Campbellpur in West Pakistan appear to indicate their Palaeolithic age though no final opinion can be expressed. These illustrations depict various mammalian types.

RESUMÉ

The story of the Palaeolithic and later stone industries of the Indian continent and Burma can now be summarised.

An important point which emerges is that the earliest stone implements found in the Indian continent (Pre-Sohan industry). occur in the Boulder Conglomerate of the Sohan Valley of West Pakistan. These belong to the early Palaeolithic and are referred to the Middle Pleistocene. No earlier artefacts are known, the Lower Pleistocene, that is, the early phase of the Great Ice Age, so far proving barren in this respect. It is equally noteworthy that two distinct types

of stone industries evolved in India side by side, namely, the Sohan and the Madras (hand-axe) Industries. Whilst the Madras Industry was closely related to the corresponding industries of Europe and the Mediterranean region, the Sohan Industry evolved more or less on independent lines, though both had meeting points at a number of places on the continent. Furthermore, though Lower Palaeolithic industries are well developed, the Upper Palaeolithic shows a lacuna, for stages like the Solutrian and Magdalenian are not easily recognisable in India, Pakistan, Burma or Ceylon. Even the Lower Palaeolithic stages, the Abbevillian, the Acheulian, etc., which have been recognised following the European nomenclature, possess certain distinctive features of their own and are better qualified as the Madras Abbevillian, Madras Acheulian and so on.

The Palaeolithic industries of Burma, represented by the Anyathian are distinct from those of India and are, on the contrary, closely allied to those of China and the Far East. A mild incursion appears, however, to have taken place into Assam. *The main characteristic of the Anyathian is the absence of the bifacial hand-axe so characteristic of the western region.* The Palaeolithic man of Burma used mainly choppers and chopping tools and hand-adzes, not hand-axes.

The Shan States region of Upper Burma does not appear to have been occupied by man during the major part of the Great Ice Age as no Lower or Upper Palaeolithic stone implements have so far been discovered there. There is, however, indirect evidence of occupation of this region by man in Neolithic times.

Another inexplicable lacuna occurs in the region to the north of the Ganga, for both the Madras and Sohan industries are absent from this region, nor has any trace of the Anyathian been found so far west. This area might well have been the meeting ground of all three—the two Western (Sohan and Madras) and the Eastern (Anyathian) industries. But our knowledge concerning this region is meagre and no definite conclusion can be drawn.

The Mesolithic, represented by Microlithic industries, is widely known in India and is also represented in Pakistan. In typology it greatly resembles the Capsian industry of the African and Mediterranean regions and that of Europe. No Microlithic

industries, in the strict sense of the term, appear so far to have been found in Burma.

The Neolithic polished hand-axe industry had a wide distribution in India, Pakistan and Burma, and appears to have attained its climax in Madras. In Ceylon, the polished stone-axe culture appears, however, to have been on the whole weak, so far as our present knowledge indicates (See p. 178).

No undoubted Palaeolithic rock paintings have so far been found in India though some give the impression of high antiquity. The same is more or less true of rock engravings. Some of the paintings and engravings are, however, likely to be of Neolithic age.

FOSSIL MAN IN INDIA

This appears to be the appropriate stage where an account of the fossil remains of man in the Indian continent might be given. Elsewhere we drew attention to the deplorable fact that not a single fossil bone had been discovered in the vast continent of India which could be assigned to a human race more primitive than any living today.

What are the causes of this lacuna, this void in the annals of research in India ?

The lack of fossils of primitive man is certainly not due to his complete absence in India, for traces of his handiwork in the shape of stone implements, engravings etc., are quite common, and he surely left his naked bones behind somewhere. Indeed India, the cradle of one of the great civilisations of the world, might well one day prove to be the cradle of humanity—the land where man first attained his man-like status, both in the physical and cultural senses of the term. This gulf is, in our opinion, due a great deal to lack of field-work and to inadequate public interest in pre-history, projects which bring immediate returns being more popular than those concerned with the origins of our race. It is, however, apparent that it is only the sum-total of knowledge which in the long run contributes towards the economic development of a country, and that often scientific pursuit which seems to possess no more than academic interest might actually have a direct bearing upon industrial development. How many among us know, for instance, that a single fragment of a fossil might tell

us that we are in the oil-bearing zone of rocks; how many of us know what wealth of coal deposits might be revealed by a microscopic speck of plant life ? And are the beauties unfolded by an insignificant chip of flint, masquerading as an implement, of no consequence at all ?

MADRAS

The Aditanallur (Adichanallur) Burials

Of the fossil remains found in India, the skulls from Bayana and Aditanallur (Adichanallur) are the most important. We have no precise knowledge of their age, yet it is probable that they are in the geological sense comparatively recent.

The prehistoric site of Aditanallur, which lies on the banks of the Tambaraparni river in the Tinnevelly district of Madras, appears to have been associated with the Megalithic culture. Here skulls and certain other selected bones (not whole skeletons) were found preserved in burial urns, some of which resemble those of Egypt. It is thus obvious that 'fractional burial', not cremation, was practised by these people. Along with the urns were found metal utensils and implements as well as stone-ware and gold-leaf ornaments.

The Aditanallur skulls are particularly elongated or dolichocephalic (Fig. 62*d*), and are not mineralised. They possess the physical characteristics of certain primitive races living in India; therefore they are of small interest from the evolutionary standpoint. There is no definite evidence as to the antiquity of the Aditanallur skulls. However, it appears fairly certain that they belong to the Megalithic culture of South India which dates back to the third century B.C. and which persisted till the commencement of the Christian era as the evidence from Brahmagiri appears to indicate. In view of this, an antiquity of about 2,300 years might be assigned to the Aditanallur burials.

Elliot Smith is of the view that one of the jaws found here indicates resemblance with that of the so-called 'old woman' of the Grimaldi race from the *Grotte des Enfants* (Fig. 62). This jaw, though its teeth are much worn, belongs in his opinion to a young individual, because the skull to which it is attached has open sutures, a combination (worn teeth and unfused sutures) also found in the Grimaldi skull. Open sutures of the skull bones

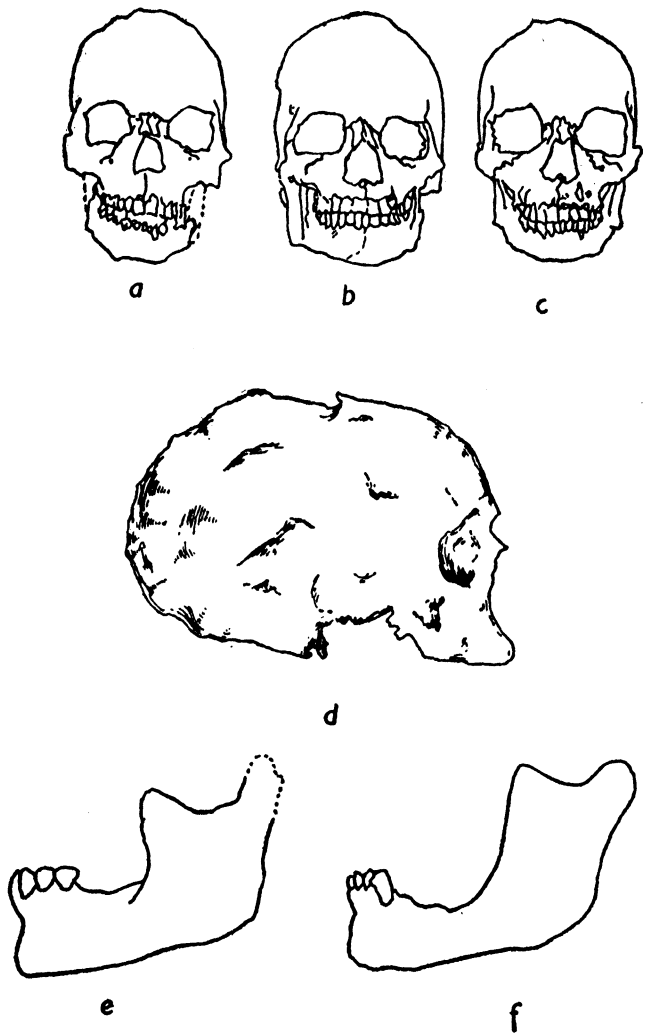


Fig. 62. The Aditanallur skull compared with the Grimaldi and modern Australian skulls.
a, Aditanallur; *b*, Grimaldi; *c*, Australian. *d*, Aditanallur skull seen in profile. Compare also *e*, the Aditanallur jaw with *f*, jaw of the "old woman" from Grimaldi. (*a-c* and *e-f*, after Elliot Smith)

are a sure indication that the owner is not over thirty (see p. 252). Moreover, amongst primitive races the teeth get worn much earlier than in the civilised races on account of the admixture of grit in their food and its coarse nature in general. Therefore amongst them worn teeth are not always a good index of age.

It is interesting to find that the Aditanallur race resembled the Australian aborigines. The Aditanallur people, therefore, belonged to the stock of *Homo sapiens*. Their successors are recognised in the various tribes of South India today. The distribution of these Australoids in the Indian continent was restricted to the forests, hills and other less habitable areas by the invasion of the more intelligent Mediterranean races. To sum up, the Grimaldi race, the Aditanallur men and the Australian aborigines appear to have some primitive features in common, as may be seen from Figs. 62 *a-c*, and Aditanallur man illustrates an important phase in the racial history of India.

UTTAR PRADESH

The Bayana Skull

The skull found at Bayana near Agra, forty feet below the river bed, is completely mineralised. Its geological age is unknown. The great thickness of deposits beneath which it was found might be taken to indicate a considerable age, and so might its high degree of mineralization. But the fluviatile deposits of the North India plains have accumulated at a very fast rate, and mineralisation sometimes proceeds rapidly. Their rates in this particular case are unknown, but are possibly high. The age of the Bayana skull therefore is possibly low. Indeed, it may be less old than the human skulls found in India of which we know more or less the exact age, namely, those of Harappa and Mohenjodaro which date back about 2,500 B.C.

According to Keith, who made a detailed study of the Bayana skull, its owner belonged to the same race that inhabits the region today. Specimens of this kind are of potential importance. Sooner or later one might be found in association with datable cultural remains. Such specimens would at least give us an idea of the rate of deposition of mud by the great rivers like the Ganga and the Yamuna.

The Gorakhpur Cranium

Another important find from Uttar Pradesh is the Gorakhpur cranium. Like the Bayana skull, this was found during the course of excavations for a bridge near Umbut on the Koana river.

It is of interest to note that the skull was associated with shells, bones, and what appear to be implements made of deer horn. The skull fragments are white and completely fossilised.

As far as can be made out, the owner of the Gorakhpur cranium was of the dolichocephalic type with a narrow, elongated head. No definite opinion can be expressed as to the age of this find. If the apparently worked deer horns are true implements, a higher antiquity might be claimed for this fossil man than is commonly accepted.

GUJARAT : WESTERN INDIA

The Langhnaj Skeletons

The most recent discoveries of fossil human skeletons, some fairly complete, are those from the Sabarmati basin, and have been referred to already (Fig. 63). Certain features of the skull and the proportions of the long bones are suggestive of negroid affinities (see p. 253).

These skeletons are associated with microliths and, therefore, may be assigned to the Mesolithic or Middle Stone Age. It is not possible at this stage correctly to assess their antiquity. But, according to Zeuner, the fact that the Langhnaj culture was soon followed by an Iron Age microlithic phase suggests that the Langhnaj skeletons are probably somewhat older than 2,000 years since the Iron Age microliths themselves are believed to date back 2,000 years. However, for correct determination of their age, further discoveries at this important locality must be awaited. This means that the pioneer work which was

Fig. 63. Skull of Microlithic man from Langhnaj, Gujarat.

commenced in this region a few years ago by Sankalia, Iravati Karve and others should be continued despite all difficulties.

FOSSIL MAN IN PAKISTAN

The Sialkot Cranium

This cranium was discovered in 1912 in a stream-cutting near Sialkot and lay buried at a much lesser depth, (only six feet from the ground surface) than the Bayana cranium. The comparatively narrow skull formed a part of a skeleton placed on its right side. The remains presumably represent a deliberate burial.

The skull is of rather friable consistency and is dull white in colour. As in the case of the Bayana find, its basal and facial portions are absent. Like the owner of the Bayana skull, the Sialkot fossil man was probably of advanced middle age. The structure of his skull indicates that he was not much different from the inhabitants living in the area to-day.

No opinion can be expressed as to the antiquity of this find, for no other fossil remains or implements were found along with the skull which could help to date it. However, the remains do not appear to be of great antiquity, particularly in view of the fact that they represent a regular burial at a shallow depth.

The Nal Cranium

This cranium was discovered at Nal in Baluchistan. It is of the elongated, dolichocephalic type and of large brain capacity, measuring about 1450 c.c. The fine, long nose suggests close identity with the present-day inhabitants of the area. According to certain authorities, the structure of the limb-bones indicates that the Nal individuals had developed the habit of squatting on the ground.

It is difficult to express any precise opinion as to the geological age of this find. An examination of the bones seems to suggest that their owner was buried resting on the left side. This mode of burial was prevalent during the Copper Age, which might suggest a reference to that period. The typical pottery found with the inhumation burials at Nal appears to suggest, however,

that the remains were contemporary with the upper levels of Harappa and Mohenjodaro. It is further possible that the early part of the Nal culture, with its Nundara' phase, dates back to the Harappa culture itself which could mean an antiquity of about 4,500 years.

CHAPTER VIII

THE PLEISTOCENE AND PREHISTORY OF CEYLON

'Land-bridges' connecting the Island with the Mainland

FOR a correct understanding of the prehistory of Ceylon, its fossil man and its Palaeolithic and Neolithic cultures, a brief account of its geological history during the Pleistocene and Recent times appears essential. This southern island has not always been separated from the Indian mainland by a stretch of sea, but was, on more than one occasion, joined to it. During these periods Palaeolithic and Neolithic man from India found his way southward either owing to climatic vicissitudes or pressure from more powerful and better-equipped races who drove him in this direction. The main fact to bear in mind is that migration took place along these so called temporary 'land-bridges' connecting the mainland with Ceylon. The southern part of our peninsula was the natural springboard for these invasions, one result of which we notice today is that the lithic (stone) cultures of the Peninsular region and Ceylon are closely related.

Geologically, Ceylon was a part and parcel of the Indian mainland (and of course of the Indo-Afro-Australian continent) for several hundred million years, possibly since the very inception of the continent. The first separation appears to have taken place during Miocene times, about 25 million years ago, when, according to Wadia, "a wide and deep arm of the Miocene sea, much wider and deeper than the Palk Strait of today, flooded the mainland between Madras and Puttalam, severing the south-east extremity of the peninsula and converting it into a continental island." Though widespread, this submergence was comparatively shortlived, and an upward movement of the ocean bed began soon afterwards, particularly in the north-west of Ceylon, and has continued with minor oscillations up to the present day, with the result that the sea in places is only 90 feet deep. In passing it may also be noted that it was about this time

(Middle Tertiary), though prior to the separation of Ceylon as a separate entity, that India acquired in broad detail its present outline.

In spite of the labours of several well-known investigators, among them the Noones (N.A. and H.V.V.), Pole, Sarasin, Virchow, Wayland and others, our knowledge of the prehistory of Ceylon is still in its infancy. The latest work is that of Deraniyagala, who has carried out important investigations on the prehistory of Ceylon and who discovered the first evidence of its polished stone-axe or Neolithic culture. He has also dealt with the equally interesting problem of repeated uplift and submergence of this region during the Ice Age, basing his conclusions upon the evidence of modern and fossil mammalian faunas and palaeoclimates. These we shall now summarise.

There is evidence to suggest that during Pleistocene times, Ceylon was connected to the Indian mainland several times. One of the most recent of these was a period of warm, arid conditions, when a number of arid-zone reptiles from South India entered Ceylon. Among these are the lizard *Lophopholis scabriceps*, the sand boa *Gongylophis conicus*, both now living in North Ceylon. The fact that these (and some other migrants) have not yet spread to the southern parts of the island proves that they are recent arrivals in the island. It is equally noteworthy that certain other animals such as the tiger (among mammals) and the *Draco* or flying lizard and the King cobra, *Naia hannah* (among reptiles) are not found in Ceylon, which suggests that they must have themselves entered India in comparatively recent times, at any rate *after* the separation of Ceylon from India. The entry of these forms into Ceylon was prevented by the arid conditions which then prevailed in the extreme southern part of India. This period coincided with the time when the reptiles (sand boa, etc.) mentioned above, entered Ceylon.

A study of the fauna of Ceylon suggests that land-connection was established between India and Ceylon during a period of cold conditions, and was followed by separation. After this, the island was reunited (and separated) more than once. We learn from our Great Epic, the *Ramayana*, that land-connection with Ceylon existed during that period. This was the last such occasion; moreover the land-bridge appears to have been interrupted by

stretches of water to which allegorical reference is made in the *Ramayana.*

It would appear that when our divine hero of the Epics invaded Lanka (Ceylon) to save his wife Sita (idolised and worshipped in India as the highest concept of womanhood) he used not only surface transport but presumably some kind of flying boats to negotiate these stretches of water. This would not be an impossibility when we consider the prevailing high winds on the sea. There is at any rate geological, zoological and archaeological evidence to prove the existence of a land-bridge between India and Ceylon. What if the facts mentioned in the *Ramayana* are in poetic or symbolic form?

Of far greater interest, though perhaps of less immediate importance to the problem we have in hand, are the three major movements of uplift which affected the island of Ceylon at various geological intervals. The last of these was post-Jurassic, probably of Pliocene age, when the uplift of the Nilgiris also took place. This uplift gave birth to the high mountain region of central Ceylon which was occupied by the Neolithic races of this island (obviously not by choice) for it was probably too cold for human habitation, since scarcely any evidence of occupation during Palaeolithic times exists. The geological dating of the two earlier uplifts is less certain but they were both pre-Jurassic. Suffice it to say, however, that after each uplift the region concerned was eroded away into a peneplain through the lapse of aeons, so that today the configuration of the island of Ceylon shows three gigantic steps, as it were, two of which are bounded by prominent escarpments. The first of these plains extends as a low region of varying width from the shore landwards; the second is equally variable in width, and has a more uneven topography, whilst the third constitutes the central *massif* of Ceylon where Pidrutgala, the highest peak, rises to an altitude of over 8,000 ft., with the lesser Adam's Peak to its south-west.

The above three regions are distinguished as the first, second and third peneplains (Fig. 64).

Palaeolithic man inhabited these peneplains, and his stone implements are found intermixed with the Ratnapura gem-gravels (whence the famous Ceylon gems are derived), between 10 and 40 ft. below ground level. It is of interest to record that

these gravels, the deposition of which was partly co-eval with Palaeolithic man, yielded crystals which were used (after only slight retouching) as implements by Palaeolithic and Neolithic man. In addition to inhabiting the first and second peneplains, Neolithic man lived also on the third and highest peneplain.

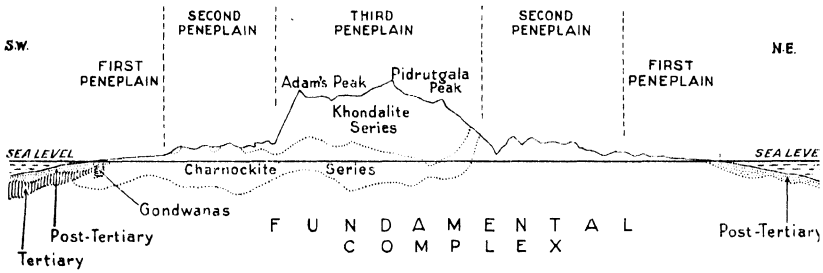


Fig. 64. Diagrammatic section across Ceylon showing the three peneplains and principal geological formations. Many important prehistoric sites occur in the escarpments surrounding the first and second peneplains. Not to scale. (After Wadia)

Climatic Fluctuations during the Pleistocene

Elsewhere we have given an account of the climatic fluctuations which affected India, Pakistan and Burma during the Pleistocene epoch. Unfortunately, in so far as Ceylon is concerned a systematic survey of the Pleistocene river terraces or of the stratigraphic sequence of its deposits has not so far been carried out. Therefore it has not been possible to determine the detailed sequence of climatic changes—of Pluvials and Interpluvials—which affected the island. There is, however, no doubt that even Ceylon, so far removed from the Himalayas where actual ice-fields existed during the Great Ice Age, did suffer marked changes of climate during this epoch, and that these affected the life and migration of Palaeolithic and Neolithic man. The evidence upon which this is based relates mainly to its fauna and flora, both living and fossil.

It is certain that when ice conditions in the Himalayas were at their zenith, cold conditions spread much further afield, with the result that some of the northern animals and plants migrated southward into Ceylon. One such instance is the pilot whale, fossils of which are found at Colombo at a depth of less than

20 feet from ground-level. The pilot whale is a cold-sea form which proves that at one time the Colombo Sea was much colder than its modern counterpart. This interval obviously corresponded to a Pluvial period. With the oncoming of warm (Interpluvial) conditions much of the fauna retreated to the Himalayan region, but left its mark in Ceylon (as also in the Nilgiris and Sikkim) in survivals at high altitudes of animals which are no different from their Himalayan ancestors of the Pleistocene.

Among such forms in Ceylon are certain hill-stream fishes, fresh-water shells and species of ants. For example, the fish *Nemacheilus botia* occurs in Ceylon and the Himalayas, but is absent in the warm intervening region. There are, similarly, other fishes whose distribution is identical. The lamellibranch *Pisidium vincentianum* occurs today only at Kandy and in the region north of the Himalayas. Among the ants, the form *Acantholepis capensis* ssp. *lunaris*, is restricted to Ceylon and the Himalayas.

Among the plants thus isolated, the *Rhododendron* which occurs in the Himalayas, the Nilgiris and in Ceylon may be mentioned.

Furthermore, in the dry regions of Ceylon there are animals characteristic of low altitudes whose relatives are found today in the southern part of our Peninsula. A combination of these two factors (occurrence of Himalayan forms at high altitudes and of peninsular forms in the arid zones of Ceylon) suggests that the cold fauna could not migrate back to the Himalayas even with the onset of arid conditions because Ceylon had *already* become separated from the mainland and that the entry of the warm fauna into Ceylon took place during a *subsequent* warm or Interpluvial period, when the Island was re-united to the mainland.

Again, excavations carried out in a cave known by the name of Ravanälla have brought to light earth layers which show evidence of past wet and dry climates, indicating alternation of Pluvial and Interpluvial periods. In this cave, evidence of at least two Pluvial periods appears to exist. It must, however, be stated that, though there is evidence of the alternation of Pluvial and Interpluvial periods in Ceylon, no detailed sequence such as is known in India, Pakistan and Burma can be made out.

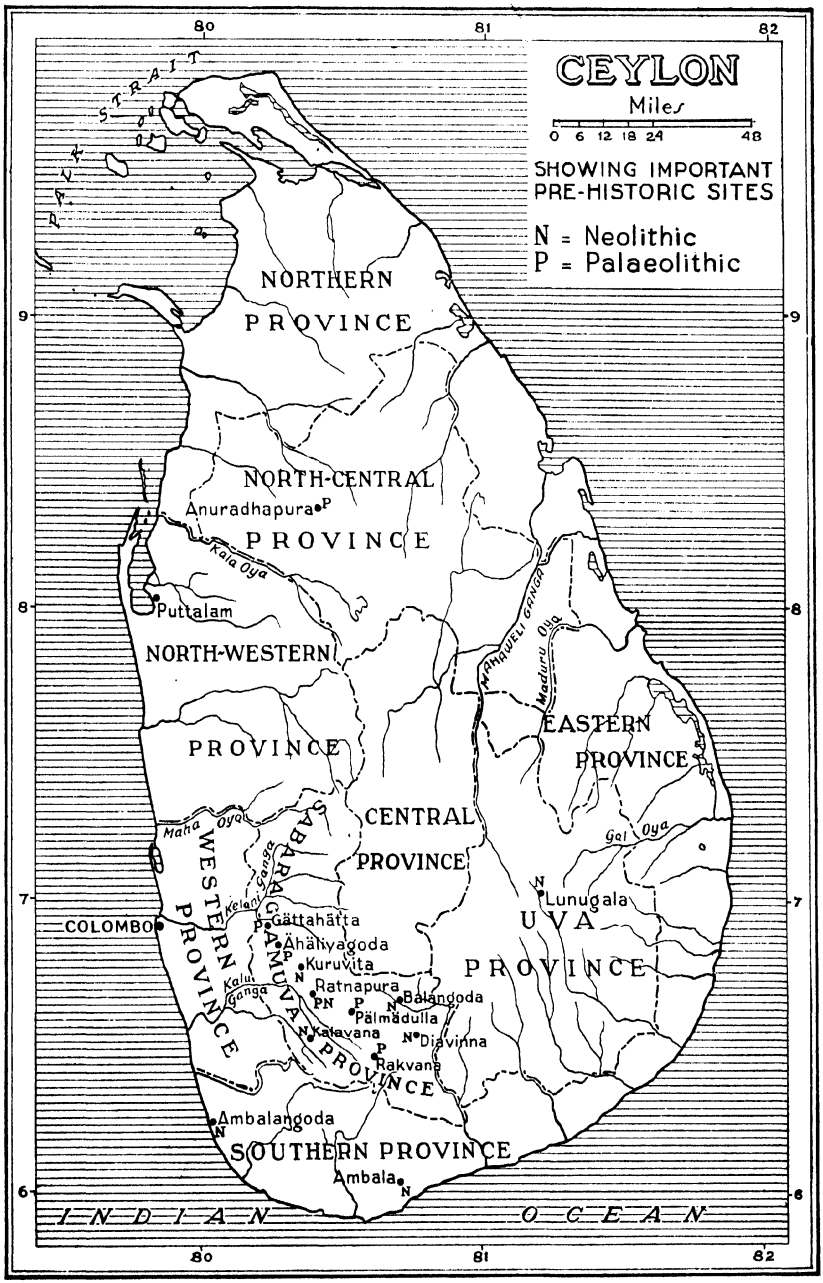


Fig. 65. Most of the important Prehistoric sites occur in Southern Ceylon.

THE STONE AGE

Until recently, Ceylon pre-historians, notably among them Sarasin, Pole, Hartley and Wayland were of the view that the Neolithic polished stone-axe industry was non-existent in Ceylon. In 1940, however, Deraniyagala found polished stone axes at Kelaniya in the Western Provinces and at Udupiyan Galge in the Balangoda district. These were supplemented by further discoveries in the Kuruvita area, proving the widespread occurrence of the polished celt.

The type-locality of the Palaeolithic culture is Ratnapura, whilst the type-locality of the Mesolithic and Neolithic is the Balangoda cave. These cultures are subdivided into the following phases by Deraniyagala. :—

Balangoda phase III	Historic / Protohistoric
Balangoda phase II	Neolithic
Balangoda phase I	Mesolithic
Ratnapura phase III, Ratnapura phase II	Palaeolithic
Ratnapura phase I	(Cultural phase uncertain.)

Further details are given below and are summarised in the Table on p. 182, while the distribution of the principal prehistoric sites is shown in the accompanying maps (Figs. 65 and 66).

The Ratnapura Culture Phase—Palaeolithic

The stone implements of this phase occur mainly in the gem sands and gravels of the Ratnapura area in the Sabaragamuva Province of Ceylon. Through this region drain the Kalu Ganga and the Kelani Ganga towards the south of which Colombo is situated.

The gem sands were formed by the disintegration of the crystalline rocks of Central Ceylon, which were the original repository of the gems. In addition to stone implements, the sands contain remains of vertebrate animals such as hippopotamus, giraffe, elephant and rhinoceros at various levels. Upon

the basis of these organic remains and the nature of the stone implements, the Ratnapura culture is divided into the phases mentioned above. Remains of plants, mostly leaf impressions,

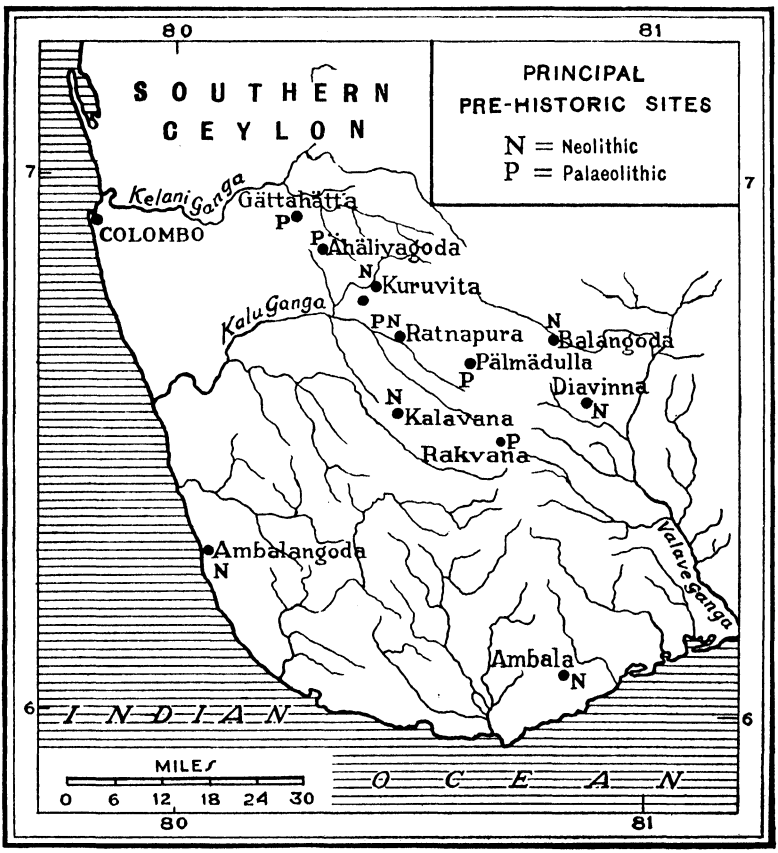


Fig. 66. Portion of Fig. 65 enlarged, showing the type Palaeolithic locality, Ratnapura, the type Neolithic locality, Balangoda, and other archaeological sites.

are interbedded with the gem sands at a number of horizons, suggesting the alternate presence of rivers (which gave rise to the sands) and lakes, in whose comparatively placid waters the plant remains were deposited. The cause of this change in the facies or nature of the deposits was none other than the earth-movements to which reference has already been made in the

opening paragraphs of this chapter. Uplift produced rejuvenation of rivers, resulting in erosion, and deposition of material as sands and gravels, while subsequent peneplanation resulted in practical absence of gradients and consequent development of lacustrine (lake) conditions. As an indirect result of these earth-movements, redeposition of the sands appears to have taken place, giving rise to an admixture containing organic remains of more than one horizon, as also in the rolling of stone implements.

The variability of the stratigraphic sequence in the Ratnapura gem pits is well brought out by the following sections exposed in different pits :—

Alutgédeniya

Humus	9 feet
Brown sand	6 "
Fine grey sand	4½ "
Leaf bed with fossils at bottom	12 "
Boulders	3 "
Dark grey grit	1½ "
Yellow ferricrete	6 ins.
White gem sand *Illama*	1 ft.
	37 feet. 6 in.

Dehigaha-tänna at Kattangé.

Mud and sand	12 feet
Leaf bed	3 "
Clay	1½ "
Illama with large pebbles, chert and tree trunks	2 "
	18½ feet

Ambalandora

Humus	3½ feet
Grey sand, blue clay and water-worn pebbles	1½ "
Lateritised gem gravel with artefacts	3½ "
	8½ feet

Ganégama

Humus	9 feet
White sand	6 "
Leaf bed and fine white sand	12 "
Illama	6 ins. to 2 ft.
	29 feet

Fig. 67. Stratigraphical sections met with in the Ratnapura gem pits. The artefacts usually occur in the gem sands or *Illama*. (After Deraniyagala)

It is noteworthy that the majority of artefacts occur in the gem sands locally known as *Illama*, and are water-worn. This implies that they were transported for long distances from places where Palaeolithic man originally lived. The fact of their redeposition

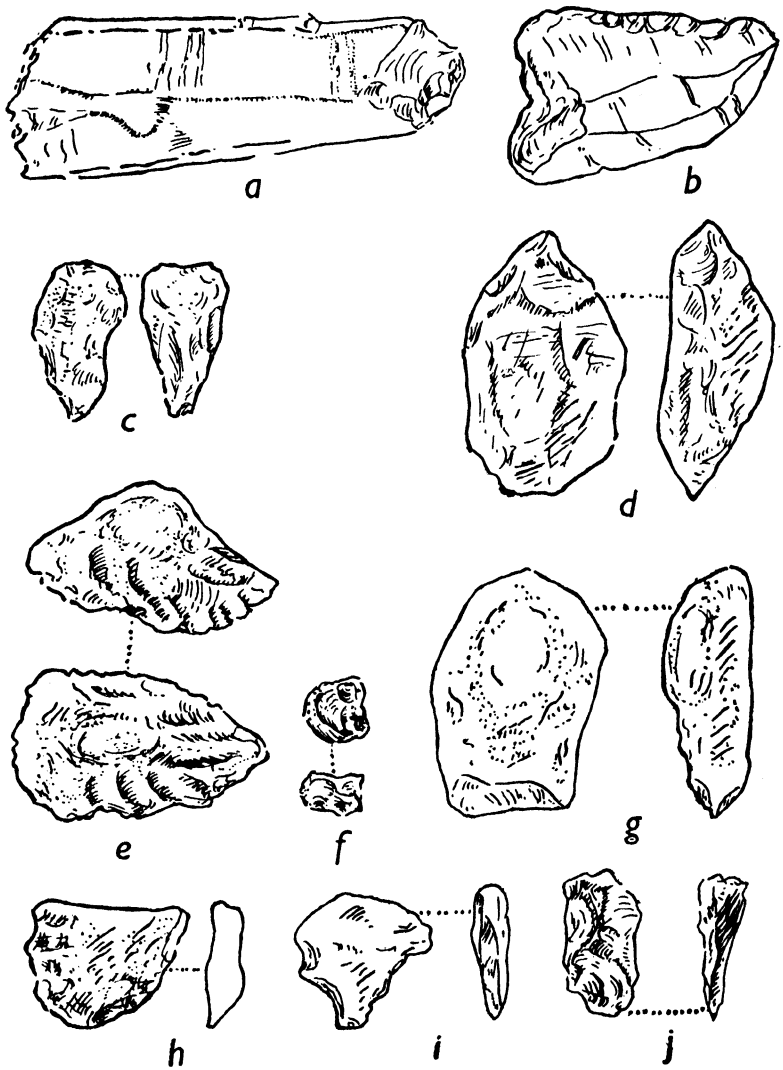


Fig. 68. Palaeolithic implements of Ratnapura Culture Phase II.
a, hexagonal rock-crystal worked at the apex; Ratnapura; *b*, pentagonal crystal showing flake scars; Ambalandora; *c*, crude *coup-de-poing*, Gättahätta; *d*, cleaver of crystal, Pannil Kanda, Rakvana; *e*, boucher of Abbevillian type; Dodampe; *f*, chopper with a straight cutting edge; Alutgedeniya; *g*, cleaver; Moratota; (*e-g*, based on pebbles) *h*, semi-lunate chopper; Narnavatte vila; *i*, flake chopper; Moraota; *j*, cleaver based on flake; Henagättha Kumbura, Ähäliyagoda. (After Deraniyagala).

perhaps more than once, adds to the uncertainty of their exact age.

Palaeolithic man in Ceylon used various types of materials —flint, chert, quartz, jasper and fossil wood—for his implements. Artefacts of fossil wood appear to be absent in the Sabaragamuva Province and are confined to the North-Western Province of

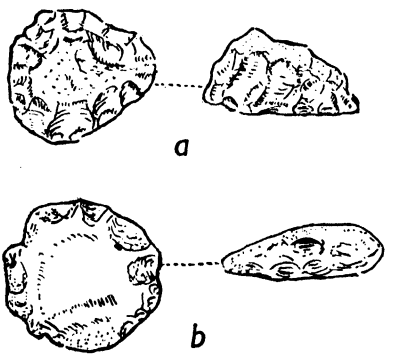


Fig. 69. Palaeolithic implements from the Ratnapura gem sands, Ratnapura Culture Phase III.
a, scraper with a concave base made from the core of a crystal, showing the Levallois technique; from Ratnapura; *b*, large, discoidal chopper of chert produced from a flake similar to the discoidal choppers from the early Acheulian; from Dehigaha tānna, at Kattange. (After Deraniyagala).

Ceylon where coniferous fossil wood is met with. The Ratnapura implements, which usually occur at depths varying between 10 and 40 ft., are based upon cores or pebbles. Flake implements and natural crystals were also in use.

We shall now deal briefly with the three cultural phases of the Palaeolithic of Ceylon.

No definitely recognisable stone implements have been recovered from Ratnapura Phase I. It seems likely that certain crystals found at this horizon were used as implements. But one cannot say this with certainty. The implements of the other two Ratnapura phases (II and III) usually lack the retouching characteristic of the later Palaeolithic stages and consist of heavy chipped flakes, or they are based on pebbles. Their typology thus relates them to the Abbevillian, though Acheulian and possibly even types suggestive of the Levalloisian are met with. Many implements from the lower levels of the Ratnapura

culture phase possesss affinity with the Sohan Industry of Pakistan, rather than with the Madras hand-axe Industry even though the Madras region lay much nearer.

In Ratnapura Phase II, various crystals worked apically or laterally or with tapering beak-like projections, have been found, whilst the *coup-de-poing* and some well-shaped scrapers of crystal are also met with. Among other artefacts may be mentioned choppers, bouchers and cleavers of various types (Fig. 68).

Artefacts of Ratnapura Phase III are usually better made. Among these are included cores shaped out of crystals, discoidal choppers of Acheulian type (Fig. 69*b*), scrapers exhibiting the Levallois technique (Fig. 69*a*), and cleavers.

Balangoda Culture Phase—Mesolithic and Neolithic

We have already pointed out that there is an abrupt break between the Palaeolithic (Ratnapura) and the Mesolithic-Neolithic (Balangoda) cultures, which suggests that when Balangoda man invaded Ceylon, the Ratnapura culture was already extinct or that, at any rate, suffered sudden and complete extinction as a result of this invasion. In his own turn, Neolithic man was ousted from the lowlands and driven to the mountainous regions of Ceylon by the influx of metal-using races. However, it can be stated that Neolithic man in Ceylon was on the whole at a lower cultural level than his counterpart in India.

The Balangoda culture phase includes the Mesolithic with its characteristic microliths, and the Neolithic with large artefacts such as ground and polished stone axes and bone implements. A very characteristic feature of many of the macroliths or larger stone implements is their pitted or perforate character.

Artefacts of the Balangoda culture are found in the Ratnapura, Balangoda and Kuruvita areas, all situated in the Sabaragamuva province. Balangoda itself is situated about 30 miles W.S.W. of Kuruvita and about 20 miles due west of Ratnapura.

Like the Ratnapura culture, the Balangoda culture is tentatively divided into three phases. Of these the earliest, Phase I, heralds the incoming of the Mesolithic industry and corresponds to a later (re-)deposition of the gem sands than the youngest

gem sand of the Ratnapura area containing Palaeolithic implements.

According to Deraniyagala, the following stratigraphic sections with redeposited gem sands (containing Balangoda implements of Phase I) are met with in the Ratnapura area :—

Mäkumbura, Mudduva near Ratnapura

Humus	6 feet
Red lateritised earth	8 "
Sand	9 "
White compacted sand	½ foot
Artefact *illama*	2 "
	25½ feet

Alutgédeniya

Swamp humus	10 feet
Leaf bed and sand	9 "
Grey sand	2 "
Coarse sand and artefact	3 "
Fine sand	1 foot
Illama	6 feet
	31 feet.

Mätivala Deniya, Pohorabava

Black humus	2 feet
White sand and artefact	6 "
Lateritic gravel	4 "
Bluish *illama*	6 in.
Graphitic *marlava* (clay)	?

Kospäla Inna

Humus	6 feet
Fine red earth charcoal, pottery and artefacts	1½ feet
Clay	?

Fig. 70. Stratigraphic sections in the gem pits of the Ratnapura area, with *redeposited* gem-sands containing implements of the early Balangoda Culture phase. (After Deraniyagala).

The other two phases constituting the upper level of the Balangoda culture have been separated upon the basis of artefacts and fossils found in the caves of the Balangoda and Kuruvita areas. Of these, the lower horizon, Phase II, contains ground and pitted macroliths while the higher Phase III, contains polished and bored implements (Fig. 71). The celt often consisted of crystal and was a hafted weapon for it was incised to accommodate a handle. The pitted pebble was also used as a hammer.

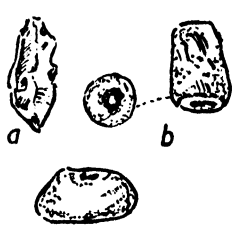


Fig. 71. Neolithic implements of the Balangoda Culture phase, *a*, celt ; *b*, polished perforated core; *c*, pitted pebble. (After Deraniyagala).

Balangoda Area

The Balangoda area lies on the first and second peneplains. Stone implements are found in the numerous caves occurring within the escarpment separating the two plains. On account of the presence of water and game which must have abounded in the neighbouring forests, Balangoda man seems to have frequently occupied these caves and rock shelters.

Two of the important caves of this area are Udupiyan Galgé near Diyavinna village, and Bambara Gala near Tanjama. We shall deal only with Udupiyan Galgé which is also the type-cave for the Balangoda culture.

The stratigraphic section in a pit sunk in the platform in front of the cave is as follows :—

Fine dust and bat guano with pottery and stone implements	2½ feet
Sand with implements	2 "
Sand with large stone implements	1½ "

From the above section it will be noted that implements commence near the surface and continue to occur in the lower levels. The presence of numerous remains of land- and water-snails, turtles, fresh-water crabs, birds, squirrels, monkeys and various other mammals gives an idea of the food traits of Balangoda man. No fish remains were found here, but these are known to occur elsewhere. Evidence appears to show that while the vertebrates were eaten after roasting, the invertebrates were saved this formality.

Among the Balangoda implements found in this cave are an ellipsoid pebble, a crude artefact of ferruginous quartz, needle-shaped and rhombic artefacts and bone implements and numerous flakes of chert and quartz (Fig. 72). The ellipsoid pebble was an artefact with one (or more) conical depressions situated laterally along each median line, and was apparently a hafted weapon, that is, it possessed a handle. The conical nature of the depressions proves the Neolithic age of the implements for pits of this shape are characteristic of the period.

It is interesting to record the occurrence of faceted haematite and graphite pebbles. The faceting was probably produced by rubbing, which shows that the material had been ground for use either for ceremonial or decorative purposes such as painting.

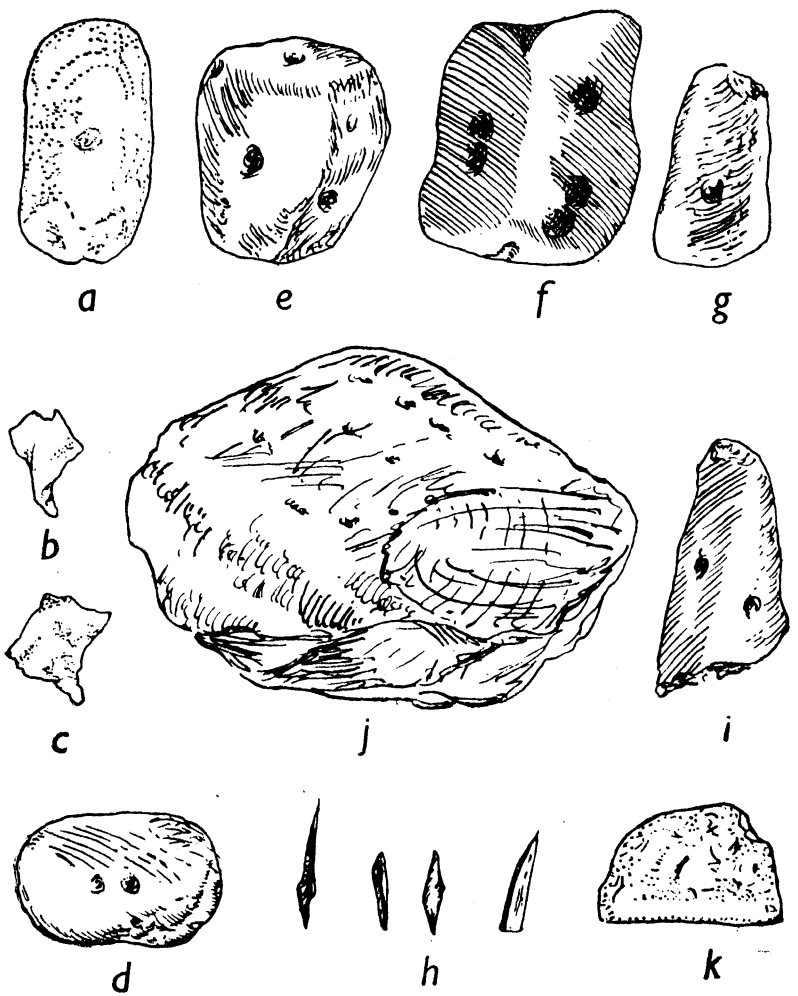


Fig. 72. Neolithic implements of the Balangoda Culture phase from the Balangoda and Kuruvita areas.
a, ellipsoid pitted pebble; *b*, and *c*, borers, from Udupiyan Galge; *d*, ellipsoid pitted pebble, from Beli Galge, Bambarabotuya; *e* and *f* pitted cuboids; *g*, pitted celt; *h*, four small single and double pointed borers of bone, from Batadomba Lena, Kuruvita; *i*, ridged celt, from Nervana gal lena, Kukulegama; *j*, anvil-cum grindstone, from Nervana gal lena; *k*. grinding implement of crystal. (After Deraniyagala)

The Kuruvita Area

The Kuruvita area drained by the Kuru Ganga, is now characterised by numerous swamps, which are the remnants of the Pliocene-Pleistocene lakes. Here again, on account of the ready access of water, profusion of fish, aquatic birds and other game, Balangoda man found convenient shelter in its caves.

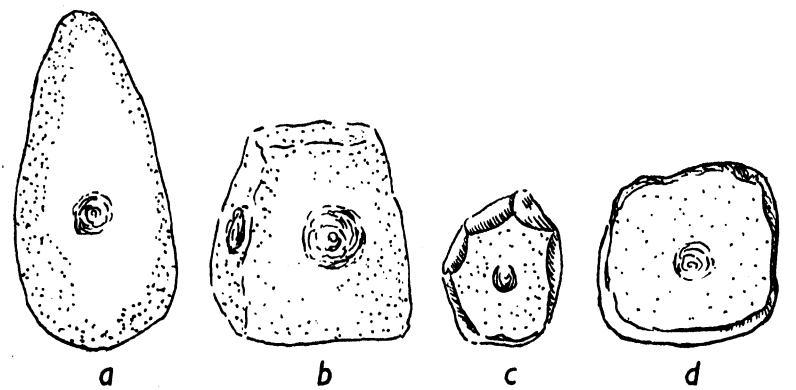


Fig. 73. Pitted Neolithic artefacts from Madras, Mysore, etc.
a, pitted celt and *b*, pitted cuboid from Bellary, Madras State; *c* and *d*, pitted artefacts from the Kolar goldfields, Mysore, for comparison with similar artefacts from Ceylon. (After Deraniyagala).

An important cave in this area is the Batadomba Lena, near the village of Valandure. We propose to confine our attention to this even though other nearby caves, such as the Batatota Lena, have been investigated.

Implements both of Mesolithic and Neolithic aspect are found here (Fig. 72). The former include the usual microliths or small stone artefacts as well as those shaped out of bone. Among the microliths are awls, borers, burins, points, etc. The most important of the macroliths or larger artefacts, are the pitted stone blocks of various shapes—cuboid, ellipsoid, ovoid, and prismoid, while some resemble hand-axes. The pits are conical in shape, which again proves their Neolithic age, for similar drilling of later times, e.g., of Bronze Age, was cylindrical in pattern. The ellipsoid pebbles resemble the one recovered from Udupiyan Galgé of the Balangoda area. The pits occur centrally along the median longitudinal line in the case of the ellipsoids

EPOCH	CEYLON'S CULTURE PHASES	CORRELATION	CEYLON FOSSILS
Post Pleistocene	*Balangoda III.* Bored and polished artefacts	Historic Protohistoric	*Elephas maximus maximus*
			Elephas maximus vilaliya
	Balangoda II. Pre-Dravidian pitted and ground macrolithic and mesolithic types	Neolithic	*Elephas maximus maximus*
			Elephas maximus vilaliya
Upper Pleistocene	*Balangoda I.* Entry of mesolithic types, a late redeposition of gem sand	Mesolithic	*Elephas maximus sinhaleyus*
			Rhinoceros sinhaleyus
			Hexaprotodon sinhaleyus
Base of Upper Pleistocene	*Ratnapura III.* Original shapes of flakes and cores altered by flaking and chipping	Palaeolithic	*Rhinoceros sinhaleyus*
Top of Middle Pleistocene			*Palaeoloxodon namadicus sinhaleyus*
			Hexaprotodon sinhaleyus
Base of Middle Pleistocene	*Ratnapura II.* Original shapes of flakes and cores retained; flaking scanty	*Levalloisian Acheulian*	*Hypselephas hysudricus*
			Hexaprotodon sinhaleyus
Lower Pleistocene		*Abbevillian*	*Giraffa*
Upper Pliocene	*Ratnapura I* Artefacts hitherto unrecognised		*Hypselephas hysudricus*
			Hexaprotodon sinhaleyus

Fig. 74. Correlation Table of the Ceylonese Stone Age cultures (Ratnapura and Balangoda Phases), and associated fauna. (Mainly after Deraniyagala)

and near the wider end in ovoids. It is obvious that the pits were used for hafting. The variation in shape of the pebbles indicates their varying functions, such as for use as hammers, celts, etc. Similarly-hafted stone hammers are in use even today in Australia and parts of India. It is noteworthy that pitted pebbles also occur in America, England, Ireland, East Africa and, of course, in India, as for example at Bellary in Madras and Mysore in Southern India (Fig. 73). Similar pitted pebbles are known from Allahabad and the Kaimur plateau in Uttar Pradesh.

Among other artefacts recorded here are anvils, pestles, mortars, grindstones and grinding stones, while the bone implements include double-pointed borers, hooks, piercing weapons, needles, etc.

A precise correlation of the various cultural phases of Ceylon with those of India or Europe is not possible in view of the paucity of data. Much remains to be done, particularly in regard to the detailed survey of the river terraces and soil deposits of Ceylon before an accurate and up-to-date chronology of the Stone Age of Ceylon can be established. Deraniyagala has however proposed a tentative correlation based upon fossil evidence and typology of implements (Fig. 74).

PREHISTORIC PAINTINGS AND DRAWINGS

So far no drawings or paintings of Palaeolithic age have been discovered in Ceylon. Our knowledge of the finer arts of

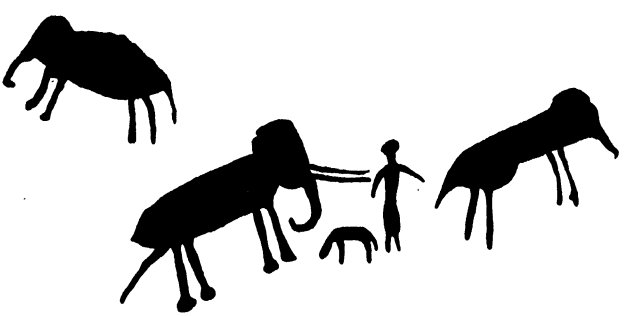


Fig. 75. Paintings of elephants, human figures etc., by Neolithic man, in the Manda Galge rock shelter, near Siyambala, Eastern Province of Ceylon. The Paintings were executed in yellow and brown colours. Note the narrow posteriors of the elephants. Similar paintings have been found in certain rock shelters on the Nile, in Egypt. (After Deraniyagala)

prehistoric man in this island is, therefore, confined to the Neolithic and later periods.

The most notable of the Neolithic paintings are those of the Manda Galgé rock shelter not far from Siyambala Anduva in the Eastern Province of Ceylon (Fig. 75). The artists appear to have employed a yellowish or brown material, presumably yellow or red ochre mixed with some oily substance to depict elephants, bears and human figures. Some of the elephants depicted possess tusks. Similarly, the drawings referred to by Still from Tantramalai and by Seligmann from Uva appear to be of Neolithic age.

Another locality where prehistoric paintings have been found is Doravaka Kanda, Kagalle district. A characteristic feature of some of the elephants depicted here, as also of those of Manda Galgé, is their projecting posteriors. Deraniyagala has remarked upon the fact that similar elephant figures have been depicted at Abka on the Nile, by Neolithic man. This similarity with a far-lying outpost of Neolithic culture is remarkable and probably indicates racial affinity. As will appear presently, it seems probable that these Neolithic races and their culture were originally native to the soil of Southern India and subsequently spread to Ceylon and to other distant regions.

MIGRATION AND DISTRIBUTION OF PALAEOLITHIC AND NEOLITHIC RACES : CORRELATION

Certain facts regarding the migration of Palaeolithic and Neolithic man from India into Ceylon and his distribution in the Island are of great interest. We shall consider the two problems together as they are obviously inter-related.

The rather crude nature of the Ceylon Palaeolithic and Neolithic stone industries, suggests that *Palaeolithic man entered Ceylon while the stone industry in India was still at a primitive stage.* That it did not advance in Ceylon even after the lapse of ages was in all probability due to lack of incentive owing to absence of competition which those on the Indian mainland had to face. As a result of this, early man in Ceylon appears to have remained at a cultural level corresponding to the Abbevillian through a long interval, whilst during this period his correlatives in India developed to the Acheulian cultural stage. In other

words, Palaeolithic man of Ceylon remained in a cultural backwater.

Another point of much significance is that Palaeolithic man appears to have become suddenly extinct in this island, and was replaced equally suddenly by Neolithic man. This may be accounted for by two reasons. Firstly, it is possible that the extinction of Palaeolithic man was due to climatic changes—the setting-in of arid conditions—which also resulted in the extinction of the hippopotamus and other larger mammals. It is equally possible that when Neolithic man invaded Ceylon from India, he was not only numerically far superior to the indigenous races but also possessed much better weapons; he was easily able to overcome the local races who thus suffered sudden extermination.

It would appear that at least two different Neolithic races from India invaded Ceylon. This is suggested by anthropological evidence, for the present-day Veddas of Ceylon 'throw back' or exhibit at least two racial types in their progeny, corresponding to the Pre-Dravidian types of India, the Kurumba, Irula and others.

The struggle for supremacy that ensued between the Palaeolithic and Neolithic races and between Neolithic and metal-using man, naturally influenced their distribution in the island. The high mountain region of Ceylon forming the third peneplain (Fig. 64) appears to have possessed a climate that was too cold for normal habitation by the tropical races. The existing fauna and fossil evidence points to the same conclusion. This is further proved by the fact that scarcely any trace of Palaeolithic man exists on this peneplain, while, on the contrary, there is abundant evidence of its occupation by the Neolithic races. This may be due to the fact that the Neolithic races were driven to these inhospitable climes by the influx of man knowing the use of metals. It is suggested that the modern Veddas are the descendants of these Neolithic races and have acquired various characteristics by interbreeding though they have not even today learnt the use of metal tools, and continue to employ stone and shells for the purpose.

In short, the Neolithic races (for there were probably more than one) remained in a cultural backwater like their Palaeolithic forerunners.

The greatest affinity of the Ceylon Palaeolithic and Neolithic cultures is naturally with those of the Indian continent and this applies particularly to the Upper Neolithic. In so far as the Palaeolithic is concerned, the artefacts of the lower levels resemble those of the Sohan Industry of Pakistan, rather than the Madrasian hand-axe industry. This is somewhat surprising. Indeed it was at one time believed that the Madras type of hand-axe was non-existent in Ceylon. However, recent discoveries (Fig. 76), few though they are, have disproved this view. A part at least of the Ceylon Palaeolithic appears to correspond to the Pinjaur Zone of the Siwaliks and the Tji Djoelang Zone of Java, because both these zones contain the same fossils ,(hippopotamuses and anthracotheriidae or horses) as the Ceylon Palaeolithic. The Anyathian of Burma may also be equated to the Palaeolithic of Ceylon upon the same basis.

Fig. 76. A crude *coup-de-poing* or hand-axe of the Madrasian type found at Udupiyan Galge Ceylon. (After Deraniyagala).

The late Neolithic of Ceylon, characterised by the pitted artefacts described already, has an even wider distribution, though all these occurrences are probably not exactly contemporaneous even though identical implements have been found in India (Uttar Pradesh, Madras and Mysore), in North and South America, England and Ireland.

According to Hooton, certain fossil human skeletons indicate that the Neolithic races of America who manufactured the pitted artefacts were of pre-Dravidian affinities. It is also believed that the makers of similar artefacts in Ceylon were likewise pre-Dravidians, though this conclusion is not based upon fossil evidence. It has been further suggested by some that the pre-Dravidians were of Indian origin and migrated to Ceylon and much later, possibly in early historic times, to America and parts of Europe and S.E. Asia. The modern Sinhalese are believed to have formed the van-guard of the Aryan invasion.

Whatever may be the exact position, this much is certain that the grand picture of the late Neolithic proves the existence of this culture over many continents, which, if it was not contem-

poraneous everywhere (as is very likely) had, nevertheless, an affinity that knits it into one inter-related unit.

FOSSIL MAN IN CEYLON

Homo sapiens balangodensis

Elsewhere we have focussed attention upon the complete absence of fossil remains of primitive, pre-*Homo sapiens* types in India, Pakistan and Burma in spite of the profuse occurrence of their handiwork in the shape of stone or other implements in these regions. The position in Ceylon is precisely similar, for with the exception of certain fossil skull fragments and a molar and incisor of *Homo sapiens* of Neolithic age, no other fossils of man have so far been discovered, even though both Palaeolithic and Neolithic stone industries are well represented.

The skull fragments discovered consist of a part of the frontal bone which was comparatively thick, as is often the case with primitive races. The skull was apparently of small dimensions but with thick though not well-defined brow ridges, and belonged to a man of about thirty. According to Deraniyagala "the fact that it was detached, smeared with haematite inside and perforated, suggests that it was part of a ceremonial burial." Some have even suggested that the piece of frontal bone with traces of haematite might have been a palette used by the Neolithic painters ! The subspecific name, *balangodensis* has been given to this human fossil representing a small statured dolichocephalic race with large teeth.

Neolithic man of Ceylon usually lived in caves, though it is possible that in later stages or under favourable conditions he built himself primitive shelters. The caves situated in inaccessible places but in the vicinity of water were usually selected for habitation. Each cave was protected by an overhanging rock-ledge, below which was a dry platform for sitting about. This protected platform also had a "look-out' rock whence the approach of an enemy could be easily detected. A collection of large boulders and stones served as ammunition in case of attack.

As indicated by the bone remains found in the caves, Neolithic man's food consisted of birds, mammals, reptiles and snails. He knew the use of fire and the art of pottery-making. The earthen

vessels were usually decorated with a wicker-basket design, which has persisted even to this day in parts of Ceylon.

Once again we are faced with an important lacuna—the complete absence of fossil remains of primitive man in Ceylon, as in India, Pakistan and Burma. Once again we emphasize the need for detailed and systematic investigation of the Pleistocene deposits and caves to enable us to come to authentic conclusions regarding early man in these regions, and to complete the picture of Indo-Ceylonese Prehistory.

CHAPTER IX

THE PRIMATES

Characteristics, Classification and Early History

BEFORE giving an account of the various fossil men, we may consider the Order Primates—the 'First of the First,' in the zoological order of rank established by the Swedish scientist Linnaeus, in 1758. The fundamental importance of this Order may be recognised from the fact that within it are included the monkeys, apes and man himself and, in descending series, the lesser Primates—the tarsiers, lemurs, and tree-shrews.

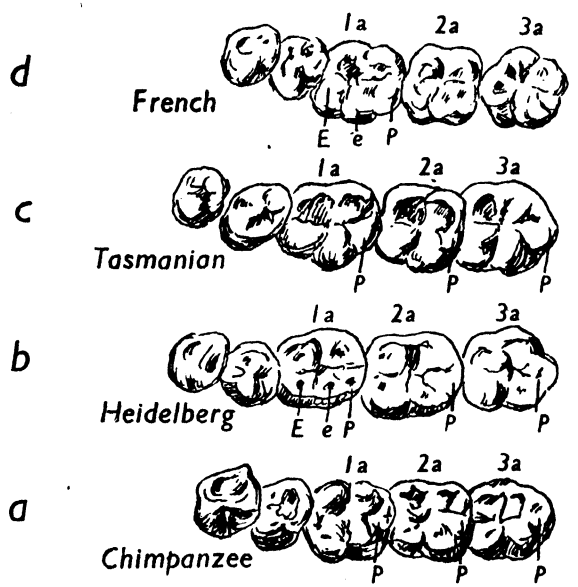


Fig. 76. Showing the relative development of cusps in the first, second and third true molars, 1a, 2a, and 3a respectively, of the higher Primates. E, *e*, external cusps, *p*, posterior cusps. The cusps are well-developed in the apes such as the chimpanzee, *a*, and even in the early fossil humans, e.g. Heidelberg man, *b* ; they become proportionately less conspicuous in modern primitive man e.g. Tasmanian, *c*, and still less so in the more advanced living races, as in *d*. (After Boule).

The distinguishing features of the Primates are not easy to define, for as an Order they are rather 'generalised', being unspecialised as regards food. They are, however, distinguishable by the following characteristics :—

1. Their intelligence is higher than that of all other animal groups, and in the higher families, they possess somewhat human characteristics.
2. They have a tendency to use their hind legs for getting about.
3. They possess two mammae situated on the chest.
4. Their highly evolved brain is much larger, *in proportion to the size of the body*, than in any other animal species.
5. Their teeth are adapted both for vegetarian and animal food.
6. They have retained five fingers and five toes, which is a primitive condition known as *pentadactyly*.
7. They have also retained the original primitive structure of their molars or grinding teeth. The cusps or prominences on the grinding surface of the molars become, on the whole, progressively less conspicuous in the higher genera (Fig. 76). In other mammals, such as the elephants, horses and their allies and the carnivores, the structure of the molars has become highly specialised, and helps us in their identification.
8. Their mode of life is mainly arboreal or tree-living, *which was probably also characteristic of the earliest mammals.* This habit was no doubt responsible for the rapid development of the brain among Primates, for it required the necessity of quick thinking and sound judgement in movement from one tree to another.
9. The opposability of the thumb and large toe and the prehensile character of the 'hand' and 'feet' are characteristic of the Primates.
10. There is a general tendency in them towards foreshortening of the face (Fig. 77), which in man has become comparatively flat. (See also Fig. 78 which represents the skull of the German philosopher Immanuel Kant).
11. We may also mention the ability to stand erect, as in modern man and in some fossil men, such as *Pithecanthropus.* Some of the modern anthropoid apes as, for

example, the gibbon, are capable of standing and walking in a sub-erect posture.

12. Lastly, a feature of great importance is the presence of flat nails in the more advanced members of the Order. Indeed, even the early Greeks realised the importance of this characteristic. Howels relates that "Plato having defined man to be a two-legged animal without feathers, Diogenes plucked a cock and brought it into the Academy, and said, 'This is Plato's man'." On which account this addition was made to the definition, "With broad nails" !

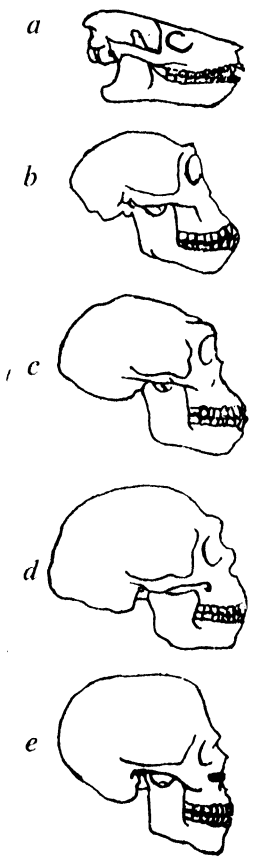


Fig. 77. Primate skulls serially arranged showing increase in brain size and gradual fore-shortening of the face. *a*, *Notharctus*, a primitive, early Eocene Primate (After Gregory); *b*, chimpanzee (After Gregory); *c*, Java ape-man (After McGregor); *d*, Neanderthal man (After Boule) and *e*, modern man (After Gregory).

Towards the end of the nineteenth century objection was raised to the common zoological definition of the Order Primates as the description applied equally to man. For this reason, man, egoist and egotist in one, not wishing to be included in the same Order as the apes, tried to found a separate Kingdom for his own species alone, parallel to that of the Animal Kingdom and the Plant Kingdom, and to name it the Kingdom of Man, we

suppose. The reason given was that man alone among animals possessed religious feelings. However, zoology and palaeontology recognise neither grades of religious feeling nor intellect, and it needed a Darwin to say that "if Man had not been his own classifier, he would never have thought of founding a separate Order for his own reception." (*Descent of Man*, 1871, p. 191). During other times, when controversies about man's ancestry were at their zenith, Huxley, one of the greatest scientists of his day, was provoked into the remark at an open meeting (where primates of another order were also present) that "it was better to be a perfect ape than a degenerate man." Coming from a lesser man such a remark would have been considered almost a sacrilege, especially during those early days; coming from Huxley, it became an axiomatic truth.

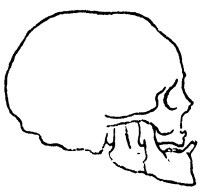


Fig. 78. Skull of the philosopher Immanuel Kant. (After Wiedersheim,)

In a work of this nature we cannot afford to enter into details of classification. However, in order to give the reader some idea of the systematic position of man and his allies, the following subdivisions of the Primates recognised by Simpson, a modern authority on the subject, may be given :—

ORDER PRIMATES

- Sub-Order Anthropoidea (Man, Anthropoid apes & Monkeys)
  - Super-Family Hominoidea (Man and Anthropoid apes)
    - Family Hominidae (Man, living & fossil)
    - Family Pongidae (Anthropoid apes)
  - Super-Family Cercopithecoidea (Old World Monkeys)
  - Super-Family Ceboidea (New World Monkeys)
- Sub-Order Prosimii (Tarsiers, Lemurs and Tree-Shrews)

ANTHROPOIDEA

Hominoidea: Man (Worldwide); Gorilla and Chimpanzee (Africa); Orang-utan and Gibbon (South East Asia)

The characteristics of modern man are too well known to merit more than passing notice. He possesses a large and complicated

brain, the largest in the Animal Kingdom in proportion to the size of his body. His face does not protrude forward, his legs are longer than his arms and he stands erect.

The anthropoids are the large apes which do not possess tails, (Fig. 79). In this respect they resemble man. They have, on

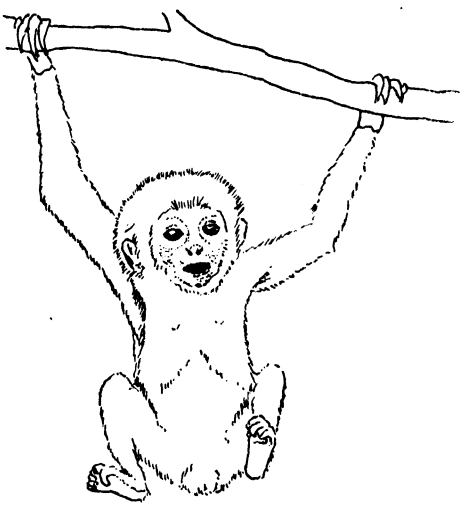


Fig. 79. The gibbon, one of the living anthropoid apes. It possesses very long arms as compared to the legs. (After Le Gros Clark)

the whole, larger brains than any of the other Primates, except man. They have a tendency towards acquiring the erect posture for which reason they are known as *Orthograde.* They are subject to the same diseases as man and their blood shows chemical reactions similar to his. Their arms are longer than their legs, the reverse of that in human beings. Four of their genera survive today, namely, the chimpanzee, orang-utan, gorilla and gibbon. The gibbon is the smallest among anthropoid apes. It walks the most erect and possesses the widest range of voice.

Cercopithecoidea (Old World Monkeys) and Ceboidea (New World Monkeys)

The monkeys are all quadrupedal or *Pronograde,* as opposed to Orthograde, in locomotion. They have, as a rule, longish

tails and their hind limbs are longer than their fore limbs. (Fig. 80).

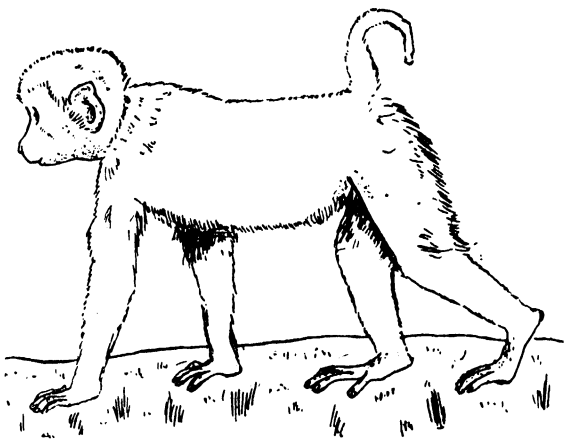


Fig. 80. The macaque or Pig-tailed monkey, *Macacus*. Its hind limbs are longer than its fore limbs, the reverse of that in the anthropoid apes. (After Le Gros Clark)

They are classified into two subdivisions which are sharply defined. In the Old World or *catarrhine* monkeys a narrow septum separates the nostrils, which are thus set close to each other, while in the New World or *platyrrhine* monkeys the septum is broad and the nostrils are well separated. (Fig. 81).

Fig. 81. The Old and New World monkeys.
a, *Cercopithecus*, one of the catarrhine (Old World) monkeys with nostrils set close to each other and *b*, *Cebus*, a platyrrhine (New World) monkey with nostrils wide apart. (After Le Gros Clark)

All the Old World monkeys are placed together in a single group, the Cercopithecoidea, and are distributed over Asia,

Africa and sparingly over Southern Europe. Among the Cercopithecoidea are macaques, the commonest of Asian monkeys, guenons, guerezas and the mangabeys of Africa, the langurs of the Indian continent, Burma, Ceylon, Tibet and Java. Here are also included the baboons and mandrills with long snouts and short tails. They mainly live on the ground in rocky areas and are forbidding in their appearance.

The present-day New World monkeys (Ceboidea) are all confined to South America. They are well adapted to arboreal life and, in some cases, their tails are prehensile (capable of grasping) and are used for bringing fruit, etc. within reach. Their arms are long (out of all proportion to their legs) and their hands serve merely for suspension, so that the thumb having lost its prehensility, has practically disappeared.

Among the forms included here are the squirrel monkey and the capuchin monkey, so called because of a tuft of black hair on its head resembling the cap of a Capuchin monk. Another genus, *Douroucoulis* has large eyes, and is adapted for nocturnal vision, whilst the so called 'howlers' produce a considerable volume of voice and are of large size. Contrasted with these, the marmoset is the most diminutive of the living monkeys.

PROSIMII

Tarsiers, Lemurs and Tree-shrews

The other sub-Order of the Primates, the Prosimii, includes three of the most interesting forms, the tarsiers, lemurs and tree-shrews.

Only a single genus of the tarsiers, named *Tarsius*, exists today and occurs in Borneo, the Philippines and the Celebes. In earlier geological times several forms were, however, known. The *Tarsius*, which is no larger than a kitten, is an animal of nocturnal habits, with a highly flexible neck and extraordinarily large eyes. It lives mainly upon insects, and moves about the trees by jumping, for which its hind limbs are particularly adapted (Fig. 82). There is diversity of opinion as to whether it is more advanced than the lemur, and therefore to be included among monkeys or whether it is a primitive form. The latter view is generally accepted today.

The lemurs are of great interest in as much as they possess structures intermediate between those of the lower Primates and their earlier forerunners, namely, such mammals as had not yet attained the Primate status. They have appropriately

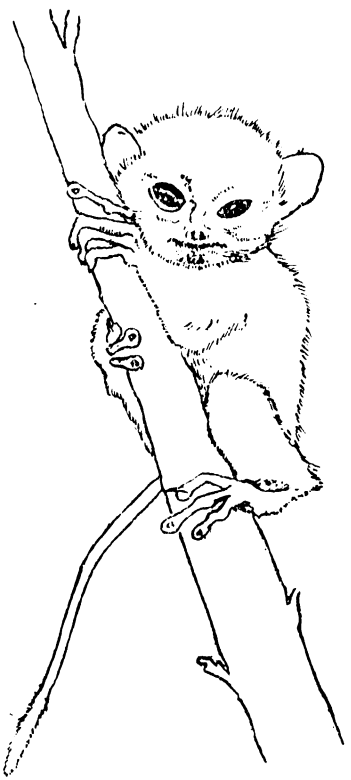


Fig. 82. Young of *Tarsius*, a near living relative of *Tetonius*, one of our remote ancestors. Our early ancestors of the Eocene period probably resembled this primitive Primate. (After Le Gros Clark)

been termed 'half-apes'. Their relationship with the monkeys is suggested by their comparatively well-developed brain, the structure of their hind limbs and fore limbs which are functionally similar to those of the apes and which possess flat nails, excepting on the second digit. In general appearance they are, however, more like the non-Primate mammals, lacking the intelligent

look of the higher Primates, which is accentuated by their long snout (Fig 83).

The lemurs are divided into two groups, namely the Lemuriformes or true lemurs, which are almost restricted to Madagascar, and the Lorisiformes, which occur in Africa and in parts of Asia.

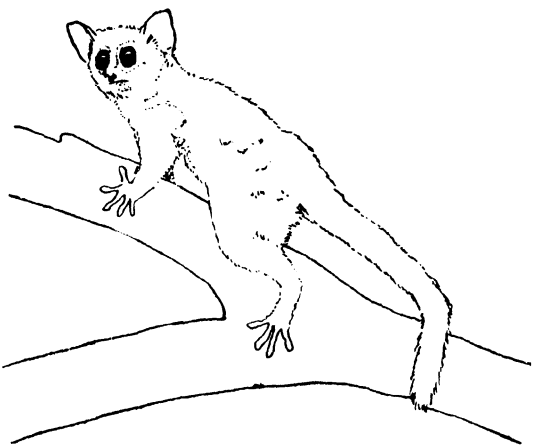


Fig. 83. The Mouse Lemur, *Microcebus*. The lemurs are primitive Primates and do not possess the intelligent look of the higher Primates. They are called "Halbaffen" (half-monkeys) by German naturalists, and some would not even group them with the Primates. (From Le Gros Clark, after Bond)

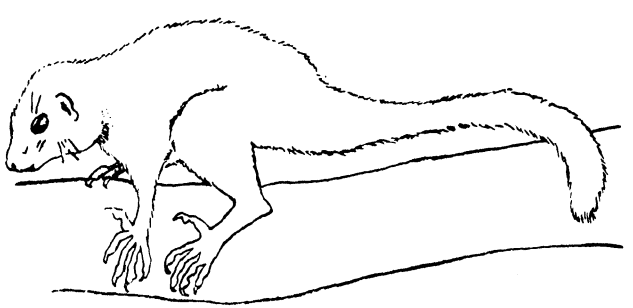


Fig. 84. One of the lesser tree-shrews, *Tupaia minor*. (From Le Gros Clark, after a photograph by Banks.)

According to modern views, *the tree-shrews* (Fig. 84) *constitute the most primitive members of the Order Primates*, Some, however, still consider that the tree-shrews belong not to

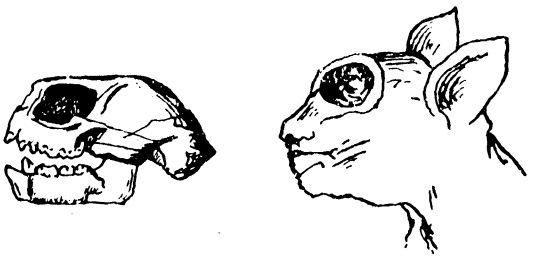
Primates, but to the Insectivores, such as the hedgehog. All recent research favours the former view. Let us then acquaint ourselves with the characteristics of the tree-shrews, this interesting and, in some ways, puzzling group of animals.

They are widely distributed over the whole of S.E. Asia, their principal Indian form being *Tupaia ellioti*, the Madras tree-shrew. Their closest resemblance in external characters is with the rodents such as squirrels. The first thing that strikes one is the functional tendency of the fingers and toes for grasping, which is so characteristic of the higher Primates. However, the fingers are provided with claws, not flat nails. We must here mention that certain extinct members of the Tupaiidae or tree-shrews possessed flat nails instead of claws, which bring them nearer the Primates than their other characteristics might at first sight warrant. The incisor teeth are different from those of the rodents while, unlike them, the tree-shrews are mainly insectivorous. Other characteristics in which they resemble the Primates are their large eyes, their comparatively large brain in proportion to that of the true Insectivores, and their poorly developed sense of smell, which is deficient also in the advanced Primates.

The early history and evolution of the Primates is of great interest, for it takes us back to our own ancient ancestors, to a period when our forerunners had just begun to assume characteristics different from those of our pre-Primate ancestors. Our remote Primate ancestors are not well known. All that we can say is that they were forms perhaps closely related to such early types as the owner of the skull to whom the name *Anaptomorphus* or *Tetonius* has been given, and which is represented in Fig. 85. *Tetonius* was of small size, being no bigger than a squirrel, and much resembled the peculiar living form the tarsier of the Philippine Islands. For this reason, some even go so far as to suggest that the tarsier is not only the nearest living relative of one of our earliest Primate ancestors, but that *Tetonius* itself is the direct ancestor of man. This form lived during the early Eocene times and possessed a more rounded skull and a larger brain (for its size) than any contemporary mammal. This last fact is important since it makes a near approach to the condition found in the apes and in man, for it is obvious that even if the brain of an elephant

or a horse is larger than that of man, it is not so in proportion to the size of these animals.

Besides their rounded skulls, both the recent *Tarsius* and the extinct (Eocene) *Tetonius*, possess very large eye-sockets to accom-



a *b*

Fig. 85. *Tetonius* or *Anaptomorphus*, an extinct Eocene Primate considered by the naturalist Cope as our direct ancestor.
a, complete skull. (After Osborn); *b*, restoration of head. (After Wilder).

modate eye-balls of corresponding size. *Tarsius*, in addition, is known to possess great flexibility of its neck vertebrae, so that it can orientate its head in almost any direction. Although *Tetonius* has been assigned to the lemurs by some authors, others even consider it closely related to the anthropoids.

We might go another step backward in the evolutionary series, and mention the still more primitive form *Pelycodus* which itself was derived from the generalised mammals. Another form, *Notharctus* (Fig. 86), can likewise lay claim to an ancestry from which the later Primates might have evolved, and it is, indeed, considered by some to be even ancestral to *Tetonius*. But unfortunately we know so little about these ancient ancestors of ours that we cannot express any authentic opinion about their exact relationship to us. The pity is that we often seem to possess the least evidence about the earliest representatives of various animal groups—evidence that in reality is of the greatest importance, for it is only from these early forms that we can get a correct picture of our ancestry.

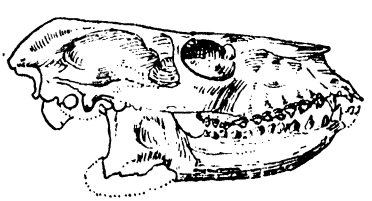


Fig. 86. Skull of *Notharctus*, one of the early (Eocene) Primates. (After Gregory)

In the case of the Primates, the main reasons for these shortcomings are that as a group they are of very great antiquity, going back at least 60 million years (early Eocene) and more; then these early forms were, almost without exception, of small size and delicate build. This not only made fossilisation uncertain, since such fragile relics would have poor chance of preservation in a forest, but the beasts of prey could afford to leave but little of their small quarry as it would hardly provide a square meal, especially if it was delicious enough !

Theatres of Primate Evolution

The above forms, *Tetonius* and *Notharctus*, and, indeed, many other early Primates, are known to have existed in the North American region, so that our early Primate ancestors appear to have been of 'New World' origin. But the land of their birth proved too inhospitable for them, and they became totally extinct there before the close of Eocene times and migrated to other parts of the world.

While the first authentic Primates arose in this area, the earliest representatives of the tailless apes, the smaller anthropoids, arose in Egypt, in Oligocene times. In India the first anthropoid apes lived during the late Miocene times. It was during this period that, besides a number of other 'man-like' apes, there lived also the famous *Sivapithecus* who was regarded by its finder as a possible ancestor of man. It is of the greatest interest to note that, just as the different grades of horses originated in a definite sequence (as we have seen), so also the Primates appeared on the scene in a definite chronological order, the most primitive ones first and the most highly evolved, last. Thus the earliest Primate-like forms akin to the tree-shrews but more closely related to the Insectivores such as the hedgehog, arose in the Cretaceous. Fossil remains of one such form represented by the genus *Zalambdalestes* were found in the Cretaceous rocks of Mongolia. From the same region is recorded the earliest fossil tree-shrew, *Anagale* in the Oligocene. The first lemurs arose in the Palaeocene and became established in the Eocene. They were followed soon after by the tailed monkeys, by the smaller anthropoid apes in the Oligocene, by the still more advanced, the larger apes such

as *Dryopithecus* in the Miocene, and finally, of course, by man himself in Pliocene times, or at any rate during the Pleistocene. It is even surmised that members of the *Dryopithecinae* may have given rise *both* to the large modern apes *and* to man.

These approximate 'dates' are given so that the reader can form an idea of the chronological sequence in which our various relatives, remotely or closely affined, originated, and of our own relative position in the genealogical Table.

It should, of course, be emphasized that in drawing conclusions concerning 'first' origins we have to depend entirely upon known data. But every ancestor *a priori* implies the existence of an earlier ancestor from which it descended. Our conclusions in regard to age must, therefore, be considered in the light of these facts, and when we say that the earliest known fossil remains of man date back to the beginning of the Ice Age, it really means that he must have originated at least in Pliocene times, if not earlier. So with other groups of animals and plants.

Did Man possess a Tail ?

There is a popular belief among the lay public that man has descended from the apes by a gradual shortening of the (at times) prehensile appendage commonly known as the tail. And, in any case, the majority appear to be certain that man or his forebears did once possess this portion of anatomy. Let us then take the first opportunity to dispel the reader's just misapprehension, and assure him that in the record of man's evolution the tail is singularly conspicuous by its absence—up to a point. For as far back as we can trace the pedigree of man, since he first attained man's estate, he certainly did *not* possess this posterior projection. However, if the truth be told, it is certain that the common ancestor of man and the apes did possess one. For if you examine the human embryo you will see that it possesses for a while a tail of quite an appreciable length (Fig. 87*a*) and cases have been known where a child has been born with one (Fig. 87*b*), showing that at some stage of our ancestry the Fates were kinder than they are today. To conclude, this much seems established: that there has been no tail in our

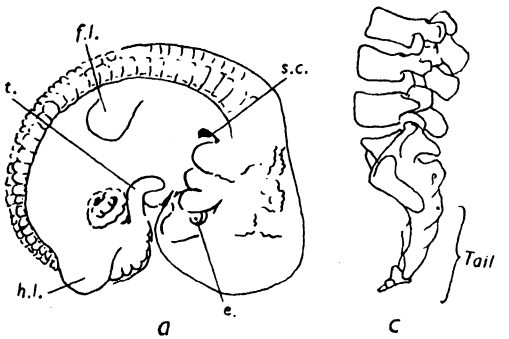


Fig. 87. Evidence of the tail in man's past history.
a, human embryo with a tail, t ; *b*, boy aged about ten with a tail; *c*, the lower end of our vertebral column which forms a true tail, but which lies hidden in our flesh; man's fish ancestry is proved by the presence of gill-clefts, s.c in his embryonic stages; (*a* after Assheton Hill and Wilson; *b*, after Wiedersheim and *c*, after Graham Kerr).

history within the last few million years, not at any rate since we acquired the human form, except an unobtrusive length that lies buried within the body (Fig. 87*c*), or protrudes in man's embryonic stages.

CHAPTER X

RACES OF FOSSIL MAN AND HIS NEAR RELATIVES

IN THIS chapter we propose to give an account of the various races of fossil man as well as of the extinct man-like apes, those strange Australopithecinae of South Africa which had almost reached the human level, and finally, of the extinct apes of India and Africa. We shall, however, deal with these in the reverse, that is the proper biological order, leaving the fossil men for consideration last.

Nature of the Evidence

The evidence upon which our knowledge of these races is based consists mostly of isolated skull-caps, teeth, leg-bones and other bone fragments and sometimes, but rarely, of complete skeletons; and, in the case of man, also of his handiwork. This ancient human industry takes the form of stone implements such as points, scrapers, arrow-heads, axe-heads, or bone artefacts and relics of contemporary art—both engravings and paintings—some of which are preserved in ancient caves and shelters. While the evidence is sometimes clear and reliable, it is as often meagre in many respects. If, therefore, the reader should think that the scientist has overshot the mark in estimating the value of such evidence, we would request his forbearance, and assure him that, invariably, the help of several experts is utilised in coming to conclusions on such important matters, though it is admitted that there are often wide differences in their interpretations of available evidence. Thus there are fossil remains concerning which there is no consensus of opinion even as to whether they belong to the ape or the human family. But there is no doubt that if we were in possession of complete skulls and other bones, it would not be difficult to assign them to their correct genealogical position. As fresh evidence accumulates, the picture becomes clearer and the pedigrees of the various races of fossil man and the apes are being founded upon surer footings.

Man's Place of Origin : Different Possibilities

We have stated earlier that the evolution of man from some arboreal (tree-living) ape-like ancestor may have taken place in the Central Asian region. But in Africa we have fossil remains of sub-human forms that possessed the straight, human type of limbs; whose skulls were devoid of prominent brow-ridges even though they had small brains like those of the anthropoid apes. Therefore, according to some, man may well be an offshoot of one of these strange African beings, and his centre of origin may equally well be Africa as Central Asia. On similar grounds, other continents and countries have an equal claim to the ancestral home of man. Thus Egypt is the centre of origin of the earliest known apes, and there is no *a priori* reason why her claim to man's birth-place may not be acceptable. The English palaeontologist, Guy Pilgrim, lays a like claim for the Indian continent, for he asserts that the extinct anthropoid ape *Sivapithecus*, from the north-west region of India, was the forerunner of man. And if we consider the known record of the ancient fossil men from Central Java, South-East Asia could well be the land of man's origin. In this island there is a remarkable chronological sequence of primitive and more highly evolved types—*Pithecanthropus erectus* or Java ape-man (Lower-Middle Pleistocene), *Homo soloensis* or Solo-man with Neanderthal affinities, (Upper Pleistocene) and *Homo wadjakensis* or Wadjak man (late Upper Pleistocene), related to the modern negritoes themselves. These probably stand in phylogenetic relationship to each other, that is, they are on the same line of descent. The discovery of a form ancestral to the ape-man would go a long way to the solution of the entire problem of the origin of man. However the recent discovery of *Homo sapiens* in Africa, in rocks which are believed to belong to the Lower Pleistocene, rather complicates the issue. The reader will, therefore, see that we do not know even today where exactly man arose, but each fresh discovery is leading us nearer to the solution of this problem.

Paucity of Human Remains : Localities of Early Fossil Men

While the human race is so widespread, it is astonishing that fossil remains of ancient man are few and far between. The

fact that primitive man occupied caves in inaccessible regions probably accounts for the paucity of his fossil bones and it is certain that many such shelters still remain undiscovered. However, it is noteworthy that ancient man appears to have taken to the caves mainly during the latter part of the Lower Palaeolithic period, that is, roughly from Mousterian times onward. Cases

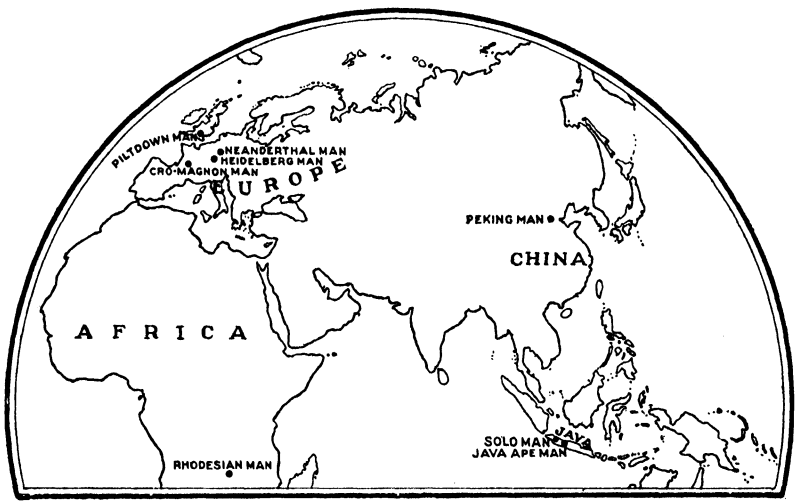


Fig. 88. Map showing localities where the more important discoveries of early fossil man have been made. No fossil man more primitive than *Homo sapiens* has been found in the Indian continent, Burma or Ceylon.

of cave occupation during the Acheulian are, however, known. Prior to the Mousterian, man was essentially a forest dweller, so that the chances of his bones being preserved as fossils were small. For it is well known that organic remains have a much better chance of preservation and fossilisation in the open country than in forests where humid weathering proceeds rapidly. Thus, fewer remains are likely to have been preserved in early, than in late Palaeolithic times. Moreover, the race of modern man congregating in great cities leads a relatively protected life, and is therefore more prolific today than ever it was before. Even today primitive races are much less productive than civilised man, and the fossil races were, similarly, not so prolific. Accordingly their fossil remains are rare.

Incidentally it may be mentioned that the physically weaker races are much more prolific than the stronger races, this being, perhaps, Nature's way of perpetuating a race which might otherwise become extinct. This can be proved so far as Indian populations are concerned by comparing the incidence of births in the virile people of the Punjab with that of the less hardy races of our eastern parts, among whom a family team of eleven youngsters (sometimes complete with an umpire and even a stand-by) is not an uncommon achievement.

In the whole wide world, the localities that have yielded fossil bones of early man are few and far between. Some of these localities are indicated on the accompanying map (Fig. 88). Fossil remains of man have also been found in other parts of the world but these are all, or almost all, of modern types, represented in the living races, and cannot be classed as missing links in the real sense of the term. In India such remains have been found at Aditanallur (Adichanallur) in the Tinnevelly district of Madras, at Bayana near Agra and Langhnaj in Gujarat. Remains of *Homo sapiens* have also been found at Sialkot and Nal in West Pakistan and in the Balangoda area of Ceylon. (see p. 188)

Similarly, though numerous human fossil remains have been found in America, some of them seemingly of high antiquity, yet physically all of them belong to the modern American Indian type, and not one is in any respect primitive. Recent evidence also appears to indicate that all American finds are, or can be, of an age later than the Last Glaciation.

I. EXTINCT ANTHROPOID APES OF INDIA

Sivapithecus

No true apes are found living in any part of the Indian continent or Burma today. In past geological times, however, our continent, or at least that part of it which constitutes the present Siwalik foot-hills, was peopled, during the time when the Siwalik rocks were being formed, by several species of these apes. Their nearest present-day relatives are among the gibbons inhabiting the tropical forests of South-East Asia, and parts of Java, Sumatra and Borneo.

One of the most interesting of the extinct Indian apes is *Sivapithecus* (Fig. 89), fragments of whose jaw-bone and teeth were discovered in the Miocene Siwalik rocks of India, near Hari Talyangar in the Bilaspur State of Himachal Pradesh, at Ramnagar in Kashmir, as well as in some parts of the Punjab and in Europe.

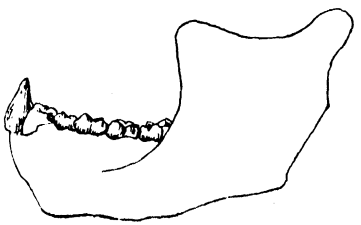


Fig. 89. Lower jaw of *Sivapithecus indicus*; an anthropoid ape from the Siwalik rocks of India, regarded by Pilgrim as the direct ancestor of man; (After Pilgrim, simplified)

The molar teeth of *Sivapithecus* resemble those of man, though the canines project above the level of the other teeth as in the apes. It is the view of Pilgrim who first discovered the *Sivapithecus* jaw that this ape stands in the direct line of descent of man. But scientists in general are not agreed upon this, and the restoration of the lower jaw from fragmentary bones and teeth has been much criticised. According to Marcellin Boule, the celebrated French palaeontologist, "the conclusion that this fossil belonged to the direct progenitors of the human race . . . contrasts with the slightness of the evidence on which it is based." Another authority considers that the present find is only the lower jaw of *Palaeopithecus*, also an anthropid ape who will be introduced to the reader presently.

Palaeopithecus sivalensis

Another large ape of which fossil remains have been found in India is *Palaeopithecus sivalensis* from the Pliocene rocks of the Siwalik foot-hills region of the Punjab Himalayas. It would perhaps not be laying undue emphasis on its human characteristics to say that it was a 'man-like' ape in a greater measure than many other apes, for *Palaeopithecus* did possess certain characteristics approaching those of man. Thus the arrangement of its teeth is intermediate between that which obtains in man and, for instance, the chimpanzee. In the chimpanzee the rows of teeth run parallel, while in man they are definitely curved anteriorly. In *Palaeopithecus*, likewise, the

two rows of teeth converge anteriorly (Fig. 90), though not quite to the same extent as in man.

Another equally important tendency towards man-like characters is that the canine and incisor teeth in *Palaeopithecus* are not as much developed as in the apes, though more so than in man.

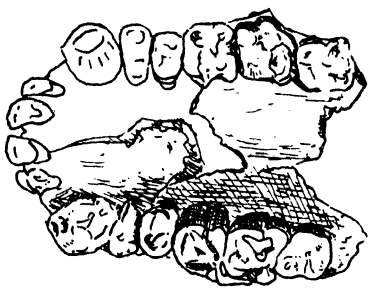


Fig. 90. Upper jaw of *Palaeopithecus*, one of the larger anthropoid apes from the Pliocene of the Punjab Siwaliks. Note that the rows of teeth tend to converge anteriorly though not to the same extent as in man. (After Lydekker)

Dryopithecus:
An Ape of the Miocene and Pliocene Oak Forests

Mention may be made of another large ape, *Dryopithecus*, whose fossil jaw-bones were found in the Siwalik rocks of the Punjab (India) and in Western Pakistan. Fossils of *Dryopithecus* have also been found in France and Germany where, indeed, these were discovered earlier than in the Punjab. The Siwalik find is of greater interest on account of the association with it of certain flints which appear to show traces of *intentional* fracturing. While there is no direct evidence that any connection exists between the two, there seems little doubt that the implements and the fossil remains are contemporaneous and this close association is certainly significant and puzzling.

Much interest centres around *Dryopithecus* and other large Miocene apes from the point of view of their relationship with man and the modern large apes. According to Le Gros Clark, "there can be little doubt indeed, that among the African fossil apes and the various types of *Dryopithecus* are to be found the ancestors of all the modern large apes." Thus, species of *Dryo-*

pithecus "show considerable variation in their dental anatomy, some suggesting an approach to the chimpanzee, some to the orang-utan, and yet others to the gorilla."

Fig. 91. Upper molars of *Dryopithecus*, for comparison with those of a gorilla. *a*, *Dryopithecus punjabicus*; *b*, gorilla. In the gorilla, the cusps are more conspicuous than in *Dryopithecus*; compare also with molars of Heidelberg man and other fossil men. (*a*, after Pilgrim; *b*, after Gregory).

On the other hand, there are various characters which suggest that *Dryopithecus* or some other large Miocene ape might even be ancestral to man. For example, the *Dryopithecus* molars (Fig. 91*a*), are much like those of some early fossil men who are regarded as on the direct line of descent of modern man, whilst the generalised limb-bones of *Dryopithecus* are also equally suggestive of a pattern from which our limb-bones could have developed.

The term *Dryopithecus* is derived from the Greek words *dryos* = oak and *pithecos* = ape, and was given because fossil oak-leaves were frequently found associated with the remains of this ape, who, it is thus presumed, lived in the oak-forests of the Miocene and Pliocene epochs.

II. EXTINCT ANTHROPOID APES OF AFRICA

Parapithecus, *Propliopithecus*, *Pliopithecus* (*Oligocene*) *Proconsul* (*Miocene*)

In the context of the foregoing paragraphs, it appears essential to refer to certain extinct apes from Africa, so as to give a panoramic view of Primate evolution. For it is from these apes that the modern forms are descended, and in them lie buried somewhere the roots of our own ancestry.

The line commences with *Parapithecus* (Fig. 92*a*), a very small and somewhat generalised form from the Oligocene of Egypt. Though remote in time, it had developed the full complement of teeth as in apes, but still retained some characteristics

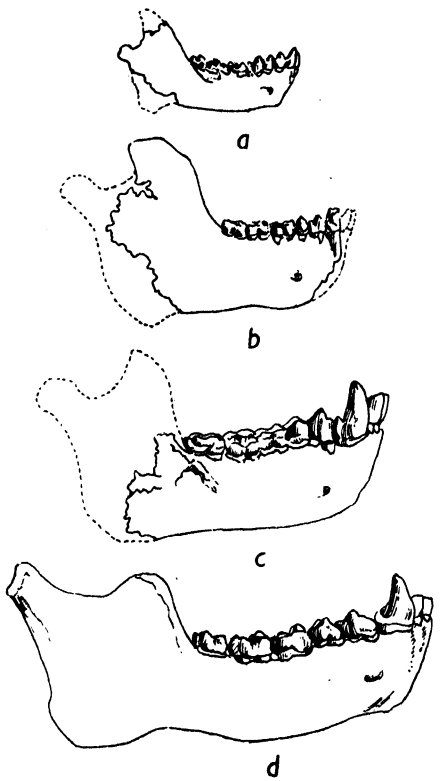


Fig. 92. Lower jaws of extinct African apes and of the gibbon.
a, *Parapithecus*; *b*, *Propliopithecus*; *c*,. *Pliopithecus* and *d*, modern gibbon for comparison with the fossil jaws. *Parapithecus* is the most primitive known anthropoid ape and is also geologically the oldest (Oligocene). It is thus about 40 million years old.

of its Tarsioid ancestry, which indicates that it might be on the direct line of descent of the super-family Hominoidea, which includes man (see p. 193).

Another ape from the Oligocene of Egypt is *Propliopithecus* (Fig. 92*b*). It was larger in size than *Parapithecus* and was progressively more evolved than the former, coming, therefore,

still nearer the modern anthropoid apes. Yet another type was *Pliopithecus* (Fig. 92*c*) which resembled the present-day gibbon in many respects (Fig. 92*d*). Thus the Tarsioids appear to have given rise *directly* to the anthropoid apes. This is a point of great significance, for it implies that the apes did not pass through a stage resembling the monkeys, which thus constitute a side-line in Primate evolution.

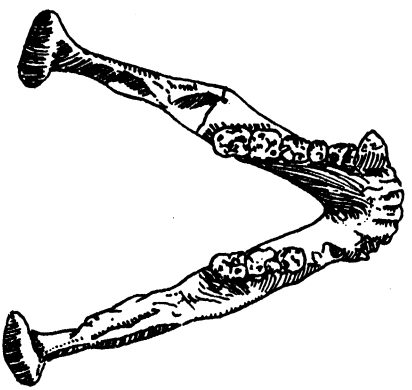


Fig. 93. Lower jaw of *Proconsul*, a comparatively large Miocene anthropoid ape of Africa. (After Le Gros Clark)

During the Miocene, several types of anthropoid apes were evolved in Central Africa, a terrain which was admirably suited for such evolution. We shall mention here only one of these, namely, *Proconsul* (Fig. 93), which may have given rise to the chimpanzee and gorilla in progressive and successive stages. This ape as well as other Miocene ones were, in spite of their size, of lighter build than the modern apes and they were comparatively well suited to living on the ground. Moreover, they possessed teeth of a generalised pattern such as might approximate to that of our ancestral forms, and their canines were small. Another important point in which *Proconsul* and other Miocene apes resemble man is the absence of a bony plate or shelf across the base of the jaw, the so-called 'simian shelf', which is present in the modern apes in the region of the chin.

From the foregoing account it is, in any case, certain that in Miocene times—long prior to the Great Ice Age—some of the

larger ape-like creatures had already begun to acquire human characteristics in many parts of the world.

III. THE FOSSIL SUB-MEN OF AFRICA
THE AUSTRALOPITHECINAE

One of the most interesting of the recent discoveries is the fossil remains of extinct man-like beings found in Southern Africa. These show striking affinities with each other and have therefore all been assigned to the sub-family Australopithecinae, recognised in 1939. Their main interest lies in the fact that their limbs were straight and definitely of the human type, even though their brains were, on the whole, relatively primitive as in the apes. Indeed, the position is that most authorities accept their sub-human status. Whilst some are inclined to regard the Australopithecinae as a specialised off-shoot of the ape stem, others regard them as directly ancestral to man.

The main reasons which favour their being classed in the human family are that, even though their brains were no larger than those of the gorilla, their premolars possessed many human characteristics, while the incisors and canines were comparatively small, as in man. Moreover, the converging, instead of parallel, rows of teeth as well as the mode of development and attrition of the successive molars was also after the human pattern. This will be referred to in detail under a description of *Paranthropus*, one of the three members of the Australopithecinae. Equally significant were the brow-ridges which lacked the bony shelf found in the apes and, therefore, in spite of their somewhat massive build, resembled the human type. The leg bones and the pelvis, which had a broad blade, also resembled those of man (Fig. 96). Finally, the insertion of the skull into the vertebral column or spine indicates an erect posture as in man, far removed from that of the apes.

The main question that arises is, whether the small brain and the skull-bone which is thicker than in man, outweigh the human characteristics in favour of closer affinity with the apes.

The three best-known members of the Australopithecinae are :-

i. Australopithecus africanus
ii. Plesianthropus transvaalensis
iii. Paranthropus

A brief account of each of these forms will now be given.

Australopithecus africanus

The first member of this sub-family that we introduce to the reader is *Australopithecus*, with whom comparatively few of us are familiar (Fig. 94). As the name indicates, *Australopithecus* (Latin, *australis* = southern, and Greek, *pithecos* = ape, i.e. southern ape) was first regarded as an ape, even if highly evolved and possessing striking human characteristics.

Fig. 94. *Australopithecus* from Africa; restoration of head. This sub-man stands on the border line between man and the higher apes and marks the nearest approach to the so-called "missing link". (After a drawing by Forestier under the direction of Elliot Smith).

Remains of *Australopithecus* were first discovered in 1925 near Taungs, Bechuanaland, South Africa, and consisted of a small skull, obviously that of an immature individual, probably not more than three years of age. The skull lay buried in limestone that was being quarried, and was entrusted by the quarry manager to Professor R. Dart for investigation.

So far as the Taungs find is concerned, the subdued brow-ridges, the shape and comparative refinement of the jaw and of the face give definite evidence of stages leading from ape to man. Exact measurements of the brain of the adult cannot obviously be estimated with certainty, but judging by the size of the young skull, the brain of *Australopithecus* must have been larger (in proportion to the size of the individual) than that of a gorilla (the largest living anthropoid ape) and, though smaller than that of man, its frontal region was comparatively well developed. As the reader knows, a broad forehead like that of *Australopithecus* is in itself an important human character and implies intelligence. In short, the entire aspect of the face taken as a whole is distinctly more human than anything known among the living or extinct apes.

Other interesting human characteristics are developed in the molar and pre-molar teeth of *Australopithecus*. Indeed these

human traits are so well marked that, had the teeth been found apart from the skull, they would have been mistaken for those of man. These characteristics combined with the human type of pelvis as seen in a very near relative, *Plesianthropus* (Fig. 96), give a unique status to this form.

The exact period when *Australopithecus* lived is unknown but it was more probably during the Pliocene period of the Tertiary era than the Pleistocene to which it had at first been assigned. All the available information leads one to the conclusion that it lived in the open country, not in forests. This probably explains its large brain and tendency towards man-like characters, for it is agreed that one of the factors which led to the development of the brain in man was that he took to the open country, where fending for himself needed much greater ingenuity than in the forest.

Plesianthropus transvaalensis or the Sterkfontein sub-man

We shall now deal with other fossil types that seem to have attained the human form in the same measure as *Australopithecus* though, as we have said before, doubt still remains in regard to their rightful status. An interesting discovery is the Sterkfontein sub-man from Transvaal, South Africa, to whom the scientific name *Plesianthropus transvaalensis* (Fig. 95) has been given by his discoverer, Broom. Others consider that *Plesianthropus* and *Australopithecus* belong to one and the same genus. In any case the two are very closely related.

Fig. 95. *Plesianthropus transvaalensis* : restoration of head ; one of the earliest known (Pliocene) sub-humans from Africa. (After Broom).

The Sterkfontein creature was of small stature, smaller than any of the living human races including the Australian aboriginals and African pygmies. While its brain was smaller than that of man, it was larger than that of the living apes. A point of

much significance is that the teeth of this sub-man were definitely human in pattern.

Besides other parts of the skeleton, the bony frame known as the pelvis, which in the female supports the unborn child, gives a sure indication whether an animal walks erect or on all fours. Now, along with the skull and other bones was found a pelvis whose structure leaves scarcely any doubt that *Plesian-*

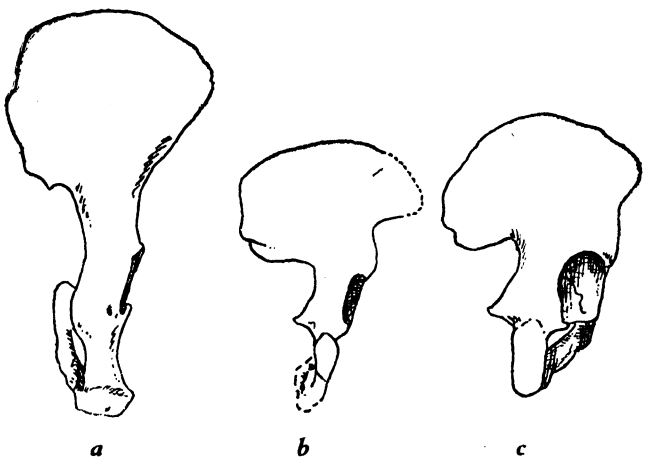


Fig. 96. Comparative studies of the pelvis in the chimpanzee, the Australopithecinae and modern man.
a, chimpanzee; *b*, *Plesianthropus*; *c*, modern man. Note that the Australopithecine pelvis is very similar to that of modern man but differs remarkably from that of the chimpanzee. (After Le Gros Clark)

thropus could walk erect. The fossil pelvis (Fig. 96*b*) resembles that of man (Fig. 96*c*), the upper part (or ilium) being very broad unlike in the apes, in whom this part is narrow and much longer (Fig. 96*a*).

The humerus and ulna, the two major bones of the upper limb are typically human while the shoulder-blade resembles that of the anthropoid apes. Although the separate portions of the skull mentioned above were found embedded in different parts of the rock, there seems little doubt that they all belong to the same individual, or at any rate to the same species.

The presence of numerous bones of fast-moving animals in the same cave where the Sterkfontein sub-man was found seems to suggest that this creature hunted animals. It is therefore

further presumed that the sub-man may have been familiar with stone implements.

Paranthropus

The most striking characteristic of *Paranthropus* is the size of the brain, which was 650 c.c. in volume and was larger by about 50 c.c. than that of *Australopithecus*. However, it may be pointed out that this estimate is based upon an incompletely preserved skull. The main reason which justifies this estimate is that "the side wall of the cranium rises almost vertically for almost 41 mm. above the temporal bones," which naturally implies a larger brain capacity than if the sides were sloping.

Another important point in favour of its human, rather than ape, affinity is the *Parathropus* jaw, particularly in respect of the different degrees to which the first, second and third molars have been worn down by use. This is due to the difference in the time-intervals between the eruption of the different molars, these intervals being longer in man than in the apes. Now in the case of some of the modern apes, the interval in eruption between the first and second molars and between the second and third molars in 3½ years. In man this interval is almost doubled, being 6½ years. This means that the human molars suffer a far longer period of wear than do the corresponding molars of the apes. An examination of the *Paranthropus* jaw shows that the first molar has been worn almost flat, while the second had suffered much less wear, and the third hardly any at all. Thus in *Paranthropus* the degree of wear undergone by the molars points to a much longer period during which the molars were in use than in the apes. In other words *Paranthropus* is more closely related to man than to the apes, hence the claim of the Australopithecinae to the status of sub-men—a claim which also appears to be supported by other evidence.

IV. RACES OF FOSSIL MAN: THE APE-MEN OF JAVA

Pithecanthropus erectus or the Java ape-man

One of the earliest known beings who may be said to possess definite attributes of man is *Pithecanthropus erectus*. He lived during the early Pleistocene times, about half a million years

ago. However, the earliest representative of the Java ape-man is a fossil child, an account of which will be given presently. The classical ape-man of Java is given pride of place here because he is so far the best known of his line. To this fossil man the very appropriate name, *Pithecanthropus erectus* (Greek *pithecos* = ape; *anthropos* = man, i.e. ape-man) has been given because of this ability to stand erect—a quality which at the time of the discovery of *Pithecanthropus,* was rather unexpected in primitive man in view of his immediate origin from ape-like ancestors. It is of interest to record that among the higher living apes, the nearest approach to this (erect) attitude is assumed by the gibbons found in parts of South-East Asia and in Malaya, and the gibbon affinity of *Pithecanthropus* has indeed been claimed repeatedly. But since the discovery of the Australopithecinae of South Africa, we know that erect posture *preceded* the enlargement of the brain. The opinion is even held by some that erect posture *had* to be developed first, before the great development of the brain became possible.

There is an interesting episode connected with the naming of the Java ape-man to which attention has been drawn by Wilder and which bears repetition here. The celebrated German zoologist Haeckel and the artist Gabriel Max, himself an anatomist, were great friends, and it is said that Haeckel had sometimes, in conversation, depicted to his artist friend the characteristics of what he thought to be the missing link between man and ape. Haeckel even gave to this imaginary being the name *Pithecanthropus* (ape-man) and by virtue (as Haeckel believed) of his incapacity for speech assigned to him the specific Greek term *alalus* (lacking speech), the full name being *Pithecanthropus alalus* or the ape-man that was unable to speak. On one of his birthdays, Haeckel was presented by Gabriel Max with a painting depicting a *Pithecanthropus* family—man, woman and infant—faithfully reproducing the hypothetical characters conceived by Haeckel and translating his speculation into tangible shape. Now, by the remotest chance, in the very same year, the actual remains of an ape-man were found in Java and his discoverer, looking for a name, hit upon the one proposed by Haeckel for his imaginary ape-man, but being uncertain about the ape-man's capacity for speech, named him *erectus* (capable of standing erect) in place of *alalus.*

Thus it was that the vision of a great scientist and the inspiration of an equally great artist were wedded together. Thus it was that science came by the name *Pithecanthropus erectus*, or the ape-man that stood erect. A similar prophetic vision is recalled to mind in the Plant Kingdom, when the celebrated botanist Saporta gave the name pro-Angiosperms (meaning forerunners of the Flowering Plants) to a group of plants, that were subsequently proven to be in fact their true ancestors !

The Discovery

The fossilised bones of the Java ape-man consisting of a skull-cap, a femur (thigh bone) and two teeth were found at Trinil on the river Solo in the island of Java between 1890 and 1892 by Dr. Dubois of Holland. They lay at the foot of the twin volcanoes Lawou and Koukousan, named, if tradition were believed, after the twins, Lava and Kusha, sons of the divine incarnation Rama. This incidentally emphasizes the close cultural relations that existed between Java and India—relics and reminders of a pristine era—and well proven from other evidence.

This was not a mere chance discovery, for the exploration of strata wherein these remains were found was carried out at the express instructions of the Dutch Government. A second effort to add to the bone remains of the Java ape-man was made by a German lady, Frau Lenore Selenka, in 1906, but though her explorations lasted eighteen months, except for a solitary tooth, no counterparts of the ape-man's bones were found. Thirty years later, von Königswald was more fortunate for he made some remarkable new finds of *Pithecanthropus* in Java including a juvenile specimen, subsequently named *Homo modjokertensis*, which will be dealt with later.

It does great credit to the western countries that their professional men—doctors, clergymen, engineers and even men and women engaged in lesser, mundane tasks—have made their contributions to scientific exploration and discovery. There is a great tradition behind them, one which our own professional men and others could usefully follow. Much remains to be done in India, for though fossil human skeletons are known, not a single bone has yet been found which could not be ascribed to the modern species of man. In other words, in this vast continent no fossil man has so far been

discovered possessing really primitive characteristics, and yet there is not the shadow of a doubt that primitive man did exist in India, as proved by the remains of his handiwork in the shape of stone implements, engravings, etc.

Comparison with the Apes and Man

Let us see what the Java ape-man looked like and how he compared with the apes on the one hand and man on the other.

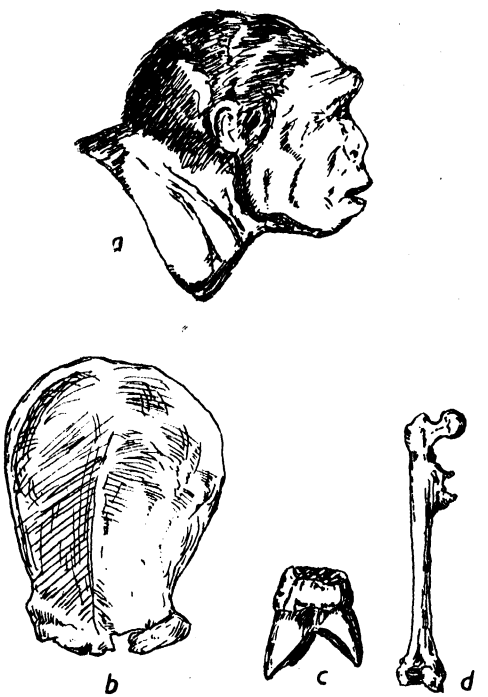


Fig. 97. Fossil remains and restoration of *Pithecanthropus erectus* or the Java ape-man.
a, restoration of head; *b*, skull cap ; *c*, third upper molar, showing divergent roots which are comparatively close-set in modern man; *d*, straight femur or thigh bone (as of modern man), with a pathological swelling (*exostosis*) in the upper part.

For such comparison a brief description of his fossil remains is essential (Fig. 97). About half a dozen skulls, some of which are more or less complete, are now known. Of the bones found, the

skull-cap is, naturally, the most important, for in it was lodged the ape-man's little brain. Except for the bregmatic elevation, his skull was apparently flattened as in an ape. The ape-man had a receding forehead and the frontal region, the hallmark of intelligence, was poorly developed. The convolutions of the brain, although similar to those of modern man, were much fewer, so that the brain surface was correspondingly less in area than in man. However, his brain capacity was much larger than that of the highest living apes. Thus we find that in regard to the brain the Java ape-man occupied a position intermediate between man and the higher apes, though in so far as his skull is concerned, he was equipped with some strikingly ape-like characters. The intermediate position is shown in tabular form below, the numerical figures indicating the cubic capacity of the brain according to Boule :—

RELATIVE BRAIN CAPACITIES

MAN	JAVA APE-MAN	APES
1,000 cc. (minimum)	850 cc.	600 cc. (maximum)
The brain capacity is never less than 1,000 cc. even in the most primitive races of modern man.		The brain capacity is never more than 600 cc. even in the most highly evolved modern apes.

But here we must sound a note of warning (which may be a source of elation to some)—that it is not the absolute weight of the brain which measures the intelligence of its owner, but the weight *relatively to that of the body*, and the volume of grey matter (and other matters if any exist), in the brain. Large heads are not always the wisest, nor big brains the best.

There are other interesting and noteworthy points about the brain of *Pithecanthropus*. Firstly, the speech centre, though rudimentary, is distinguishable, suggesting that he possessed the power of speech, however feeble. (The speech centre develops progressively as we ascend in the scale of human evolution, and the capacity for coherent speech increases). Secondly, the left side of his brain was somewhat larger than the right side, which indicates that the Java ape-man was right handed, like modern man. Right-handedness is thus a very ancient trait of man.

We shall now see what story the ape-man's other remains have to tell.

Strangely enough, of the many bones in the human body, the teeth are of prime importance in establishing relationships between different species. When you next have toothache and visit a dentist of the pull-at-first-sight variety, you will have a good opportunity to compare your teeth with those of *Pithecanthropus* and the apes. You will then observe that the ape-man's molars are larger than yours and possess widely divergent roots, as in the apes (Fig. 97 *c*). But they are broader than they are long, the reverse of what we find in the apes, in which respect they are human in type. In other words, the *Pithecanthropus* molars exhibit some human and some ape characters, a statement which is equally true in regard to his skull and brain.

The most astonishing feature about *Pithecanthropus*, is his straight thigh-bone (Fig. 97 *d*), which is scarcely distinguishable from that of modern man. This implies erect posture, which is surprising when one considers that *Pithecanthropus* is one of the earliest of fossil men and would therefore be expected to have retained the bent posture of his immediate ancestors. Strangely enough, this characteristic is actually found in a succeeding race—the Neanderthalers. But as we explained earlier, evolution leaves an unequal impress upon different organic beings, resulting in unexpected combinations. Careful examination of the leg and other bones by experts appears to suggest that, though he stood erect, the ape-man could climb trees much more readily than modern man. Another point of minor interest (not being a doctor, one can divulge it) is that this ape-man suffered from an *exostosis* or a pathological swelling of the thigh-bone which undoubtedly gave him a good deal of pain. (Fig. 97*d*).

There is evidence to show that the Java ape-man knew the use of stone tools. These were, however, of exceedingly crude manufacture.

Now the important question arises, what is the exact relationship between modern man, *Pithecanthropus erectus* and the apes ? Three possibilities are suggested by different scientists: that the ape-man stands on the direct line of descent of modern man as appears from the genealogical tree in Fig. 98 *a*; or that he is a side branch of the main human stem as shown in Fig. 98 *b*; or finally that he is no more than a highly evolved ape (Fig. 98 *c*), like the modern chimpanzee, orang-utan or gibbon. These are questions that cannot be satisfactorily answered at

this stage, but if one were to hazard an opinion, the Java ape-man appears to lie on the direct line of descent of modern man to whom he gave rise after passing through a Neanderthaloid stage.

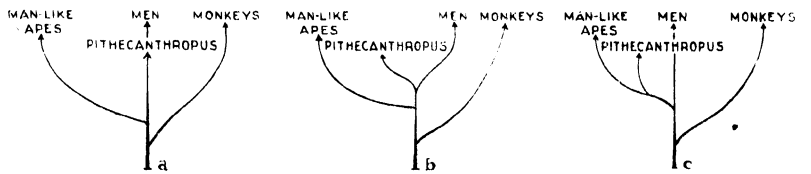


Fig. 98. This illustrates the genealogical position of *Pithecanthropus* or Java ape-man. According to *a*, *Pithecanthropus* lies on the direct line of descent of modern man ; *b*, suggests his origin as a side-branch of the main human stem ; *c*, shows that he is only a side-branch of the ape-stem i.e, one of the anthropoid apes. (Adapted from Boule).

The Geological Age of the Java Ape-man; Geography of the Period

Geological age, as we have stated earlier, cannot be determined with mathematical exactitude, but in the opinion of many geologists, the Java ape-man dates back something like 500,000 years. This takes us to the early part of the Great Ice Age—the Pleistocene period of geological history, while others assign him to the Second glacial (Middle Pleistocene). The earlier age of the Java ape-man is, however, now generally accepted. The original find of the Java ape-man is not the earliest known among fossil men. This distinction is now given to a fossil child's skull of about six years of age to whom the name *Homo modjokertensis* is given (see p. 226). He also belongs to the *Pithecanthropus* race in the wider sense. Some even assign him to that genus.

Of equal interest are the plant and animal fossil remains found along with *Pithecanthropus*, as they not only afford evidence of age but also of the physical conditions prevalent contemporaneously with him. They indicate, for example, that at least during a part of the period when the ape-man lived, the climate of Java was wet, the rainfall higher and the temperature lower by five or six degrees than at the present day, and that the region was covered by a thick forest growth. He was, therefore, a forest-dweller. Some of these contemporary remains, as for example,

of the extinct elephant *Stegodon*, show relationship with those of the late Tertiary and Lower Pleistocene of India (Assam) and China which suggests that a land-bridge over which the ape-man trod extended from the island of Java to the Asian mainland. This land-bridge is now submerged under the Java sea. The island of Java was still connected to the mainland in Middle Pleistocene times by a narrow strip of land and finally became separated as a distinct entity in late Upper Pleistocene times owing to continued uplift.

Java Ape-man helps in detecting the Causes of Crime; Landru and his Fair Victims

At this stage, we propose to enter into a digression and consider certain aspects of the subject which not only throw valuable light on organic evolution, but from which legislators, law-makers, medical men, teachers and parents can learn much to understand their fellow beings and their actions, and thus help to ameliorate the lot of the human race.

Many of you (the fair sex, we hope, in particular) must have heard of the French arch-criminal Landru, an outwardly most amiable and refined gentleman who decoyed women with his charming manners and confessions of love, and finally murdered them in cold blood. And, as if to compensate them for the inconvenience caused, he later consumed them in a warm fire, lit in a stove. Now you will surely enquire, What has any criminal and his winsome female victims to do with the problem of man's evolution ? Let us explain. Monsieur Landru was ultimately discovered and apprehended by the police, and when his remarkable criminal career became known, he was very wisely subjected to a thorough examination by medical and mental experts. And it was found that in his venerable skull there was an elevation (appearing, of course, as a depression on the inside of the skull) such as is found in a subdued form in the ape-man of Java, and which anthropologists call the Bregmatic Cistern. Now this elevation which is a sign of the primitive and which man has since nearly lost in the course of evolution, may occasio-

nally be developed in a pronounced degree even in modern man. Such was the case with Landru (Fig. 99), and it was these primitive traits that may have been responsible for his anti-social instincts and murderous proclivities, for it meant that by a process of reversion (evolution in reverse gear) which sometimes takes place, Nature had saddled him with a brain that was primitive in certain features. No wonder then that he was well gifted with bestial instincts. It was a relic of man's past, a heritage from his ape-like ancestors.

Fig. 99. Portrait of Landru, showing an abnormally developed Bregmatic Cistern.

But in fairness to Mon. Landru it must be said that if he possessed such a brain, was it his fault ? Some might say no. It was, as we have said before, a legacy, an inheritance from the past, and the man who possessed it could no more help, or be responsible for, his criminal nature than an infant could help sucking its mother's breasts when hungry. It would indeed be strange, with our ancestry of protozoa, coelenterates, lancelets, 'sea potatoes', fishes, amphibia, reptiles and ape-like creatures, if it were otherwise. *Therefore, the criminal should be treated in the light of his biological past*, and not entirely in the light of his present environment.

What a man achieves mentally and morally during his lifetime is partly (perhaps mostly) the result of the qualities he has inherited and partly the result of environment and upbringing. But even if you can never obliterate the fundamental, the basic characters that he has inherited, these are always amenable to treatment and it may even be possible to suppress them. Therefore, it seems to stand to reason that much responsibility attaches not only to parents but also to law makers and educationists who, instead of attacking the causes of crime, some of which are purely biological, merely punish the criminal after the crime has been committed. There can be no doubt that the problem has to be approached from the evolutionary and biological stand-

point; it may thus be reasonably claimed that even the study of fossils and anatomy may contribute much towards improving the lot of the human race.

Homo modjokertensis

According to recent discoveries the fossilised skull of a child found near the village of Modjokerto in Java by the Javanese collector Andojo, and later reported upon by Duyfjes and Von Königswald represents the earliest known fossil man from Asia, indeed from any part of the world. He is believed to have lived during the First Interglacial period, the comparatively warm interlude following the First Glacial episode of the Ice Age, which gives him a higher antiquity (about 600,000 years) than that of the famous Java ape-man.

The child was probably about six years of age, and possessed a smaller brain than that of a modern child of the same age. The forehead was low and receding and the brow-ridges heavy, both suggestive of the Java ape-man. Therefore, the child probably belonged to the *Pithecanthropus* race and may have been a forerunner of the Java ape-man himself. These views are now accepted by modern authorities.

Pithecanthropus robustus

We have just referred to the recent discovery of fossil remains which probably represent a close relative and ancestor of the well known Java ape-man. An even more recent discovery is yet another species of *Pithecanthropus*, found as recently as 1939 by von Königswald in Central Java, from the same locality as the giant ape-man, *Meganthropus*, to be presently described. As we have already dealt in detail with the classic Java ape-man we need not say much about the new find except that the skull was vertically depressed. For the rest, the reader is referred to the restoration of the skull (Fig. 100*a*). We may, however, bring to the reader's notice one other point of interest—that the skull of this individual (Fig. 100*b*) was almost double the thickness of the skull of

present-day man (Fig. 100 *c*), thick skull-bones being a primitive character. The thick skull gives him the name *robustus*.

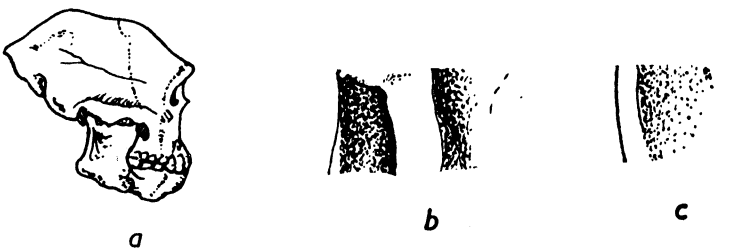


Fig. 100. *Pithecanthropus robustus*, a near relative of the Java ape-man. *a*, skull in profile; *b*, shows its thickness which is far greater than that of the modern human skull, *c* ; (From "Life", October 1946)

Meganthropus, the Giant Fossil Man of Java

Another recently discovered fossil man has been named *Meganthropus* (Greek *megas* = large, *anthropos* = man, that is, a giant man). His remains were also found by von Königswald in 1941 in ancient lake deposits in Central Java, near those of *Pithecanthropus robustus*.

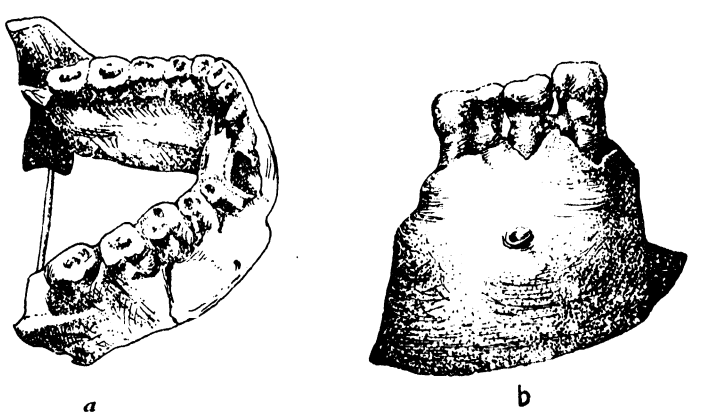


Fig. 101. *Meganthropus* jaw. *a*, restoration; *b*, portion of jaw-bone with three attached teeth. (From "Life", October 1936)

Unfortunately, *Meganthropus* is known only from a portion of the jaw and three teeth still attached to it (Fig. 101*b*). Nothing

is known of the other parts of the body, but judging by the large jaw-bone, he must have been of unprecedented size, and modern man would look a pygmy beside him.

Homo soloensis or Solo Man

Between 1932 and 1937 several skulls belonging to an extinct human race were discovered by Oppenoorth near Ngandong, not far from Trinil, well-known site of the Java ape-man. This fossil man has received the name *Homo soloensis*. He was more advanced than the Java ape-man in possessing Neanderthaloid characteristics for which reason he is sometimes described as *Homo neanderthalensis soloensis*. However, according to Oppenoorth, *Homo soloensis* differed culturally from the Neanderthalers in that he knew the manufacture of bone and horn tools, whereas the Neanderthalers used only stone artefacts. That he represents a higher stage of humanity than *Pithecanthropus* follows *ipso facto*, for as we have already seen, the use of such artefacts came much later than *Pithecanthropus* and *Sinanthropus* or even the more advanced Neanderthal man about whom the reader will learn presently.

The associated fauna and other geological evidence suggests that *Homo soloensis* lived during the Third Interglacial period. During this period, the Sundaland was brought into existence by a lowering of the ocean level, as a result of which, a temporary land-connection was established between Java and the Asian continent across which *Homo soloensis* must have migrated to the island.

Homo wadjakensis or Wadjak man
The Modern Negrito Races

In order to complete the picture of the succession of races of fossil man in South-East Asia, we shall refer here briefly to *Homo sapiens wadjakensis* even though this makes a departure from the scheme adopted in this book, since we have dealt with fossil *Homo sapiens* in a separate section.

Fossil remains of *Homo wadjakensis* were found in Java in 1889-90 by Dubois, though they were made known to the world about three decades later. This fossil man was far more evolved than *Homo soloensis* and is, in fact, included in the modern

human species. Some authorities, notably among them Keith, regard this human type as related to the Australian aborigines, if not directly ancestral to them. In fact it is believed that the various fossil men—*Homo modjokertensis*, *Pithecanthropus erectus*, *Homo soloensis* and *Homo wadjakensis*—found in Java in successively younger formations, represent an ascending series in the scale of human evolution along a common line of descent, culminating in the modern Negrito.

Homo wadjakensis lived probably during the Fourth Glacial epoch and may have entered Java during the period of low sea-level which occurred during this time and which once again brought about land-connection between the island and the main continent. The ancestors of the modern Negrito races probably migrated to these islands near about the close of the Pleistocene period. This event was followed soon after by their migration further east as far as Australia.

V. FOSSIL MAN IN CHINA

Sinanthropus pekinensis or Peking Man

The skeletal remains of the Peking man, consisting of two isolated teeth, were first discovered by Zdansky in 1926 at Choukoutien, about 26 miles to the south-west of Peking. In the wake of this discovery another tooth was found. To the owner of these teeth, Davidson Black gave in 1927 the name *Sinanthropus pekinensis* or Peking man. Three years later, a more or less complete skull was discovered by the Chinese palaeontologist W. C. Pei. In course of time, remains of over 40 individuals of both sexes and of varying ages were discovered, so that our knowledge of the Peking man is now based upon more material than in the case of almost any extinct human race. There is no doubt that Choukoutien was a large settlement of the Peking man, for apart from their prolific occurrence, the fossil remains are found associated with numerous kitchen hearths.

The Peking man represents a very primitive type of humanity. He was, at any rate, not more advanced than *Pithecanthropus*. Indeed most authorities now consider that racially he belongs to the Pithecanthropoid group, and many would even place him in the genus *Pithecanthropus*. In common with the Java ape-man,

he possessed a low, receding forehead, thick brow-ridges and powerful neck-muscles (Fig. 102).

Stone implements occur along with the bone remains of Peking man. A point of particular interest is that these implements are

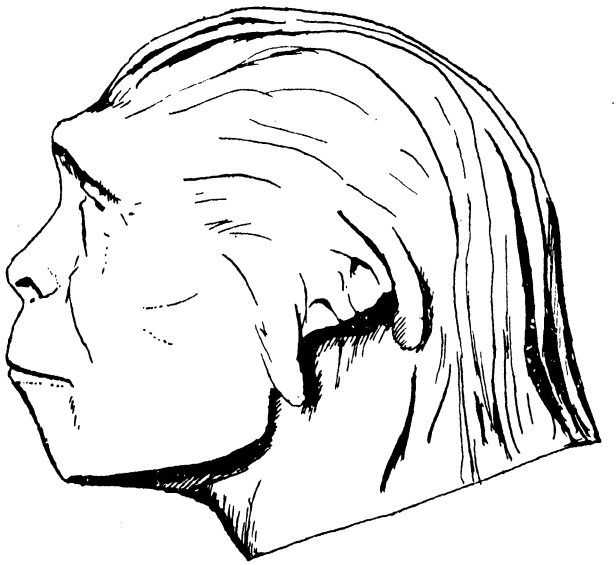


Fig. 102. Restoration of the head of Peking man, *Sinanthropus pekinensis*. Peking man and Java ape-man are considered by some to represent geographical races of but one and the same species under *Pithecanthropus*. (After Wiedenreich)

somewhat different from the usual Palaeolithic implements of the same age found in Europe or even in India, partly because the raw material from which they were made was different and of very poor quality.

Peking man lived during the First Interglacial period. The presence of the kitchen hearths referred to above indicates that even at this early date, man knew the use of fire. It will be noted that the Peking man was a part contemporary of the Java ape-man.

VI. FOSSIL MAN IN EUROPE

The Swanscombe Skull

We shall now give an account of a very important fossil skull discovered in 1935 at Swanscombe in Kent, England. The skull-

bones were recovered from the Barnfield pit excavated in a 100 ft. high river terrace of the Thames. The importance of this unique discovery lies not only in the fact that the locality and its age are definitely known, but also that the bones were associated with stone implements of undoubted Acheulian age. If

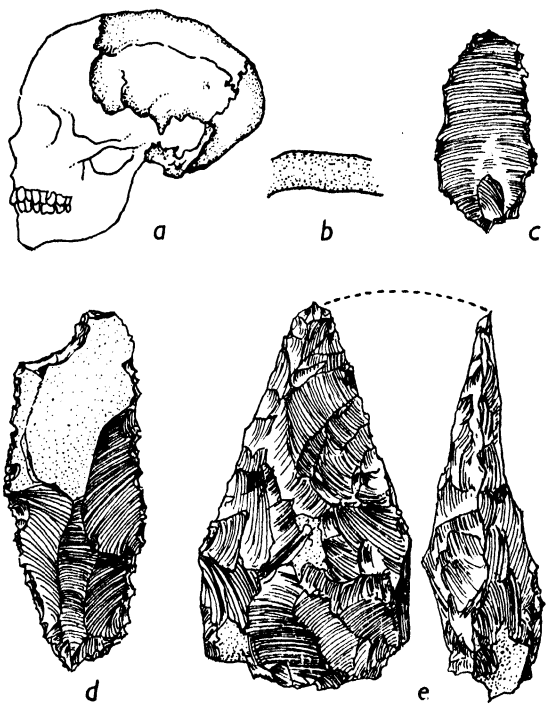


Fig. 103. Swanscombe skull and associated stone implements.
a, restoration of skull; *b*, portion of the skull-bone showing its excessive thickness; *c-e*, various types of stone implements found with the Swanscombe remains. (*a*, after Howells; *b—e*, after Swanscombe Committee report.)

you refer to page 125, you will see that this subdivision of the Palaeolithic is a relatively early one, so that these relics are of great antiquity, dating back to the Second or Great Interglacial period. This implies that Swanscombe man would have lived about 250,000 years ago.

Unfortunately, the few bones found do not give us a correct idea of the entire skull since only fragments of its back portion are preserved. Such observations as we can make seem to indi-

cate that the owner of the skull was probably a woman of about twenty-five or slightly younger and possessed characteristics not different from those of *Homo sapiens*. Her brain capacity was about 1325 cc. which would do credit to some of the primitive living races and which approximates to the average brain capacity of modern man. The one difficulty here is that so far no remains of *Homo sapiens* have been found with certainty in rocks of such high antiquity. Moreover, certain parts of vital importance are missing (Fig. 103*a*), and it would not be altogether surprising if the skull turns out to be that of a human type not quite identical with *Homo sapiens*, considering more particularly the great antiquity of the remains. The excessive thickness of the skull-bone (Fig. 103*b*) as compared with that of modern man lends further support to this view. But when we attempt to trace her affinities, it is found that the Swanscombe lady almost certainly did not belong to any of the known primitive fossil types, such as are represented in the Java ape-man, the Peking man or even the Neanderthal man (see p. 237).

The mammalian remains found with the Swanscombe skull consist of the elephant, *Elephas antiquus*, *Bos* and rhinoceros, which proves that this region of England (then probably joined to the mainland) was a woodland during those days, and that its climate was warmer than it is today.

The stone implements used by the Palaeolithic men of Swanscombe were of the primitive type, consisting of flint cores and Acheulian hand-axes (Fig. 103*e*). There are also many Clactonian flakes in the deposit from which the human remains were recovered (Fig. 103*c*).

Eoanthropus dowsoni or the Piltdown man

We cannot better introduce the Piltdown man to the reader than by telling a story. In a certain town there lived a man who was habitually shabbily dressed, not at all in keeping with his high position, and was, indeed, well known to all and sundry for this trait of his. One evening, after a few days' absence from town, he turned up at the club in a smart suit of clothes, whereupon his friends collected around him, and anxiously enquired if he had picked up the wrong luggage in the train. The Piltdown man, as the reader will presently see, has something in common with the aforementioned gentleman.

As the name indicates, the skeletal remains of the Piltdown man were found at Piltdown in Sussex, England. This fossil man is known from portions of a skull, a fairly well-preserved jaw and teeth, found in 1911. The skull and the jaw were, however, found some distance apart even though in the same gravel-bed. Since they both occurred in gravels and are slightly water-worn, it is more than likely that they may have travelled some distance along an ancient water-course.

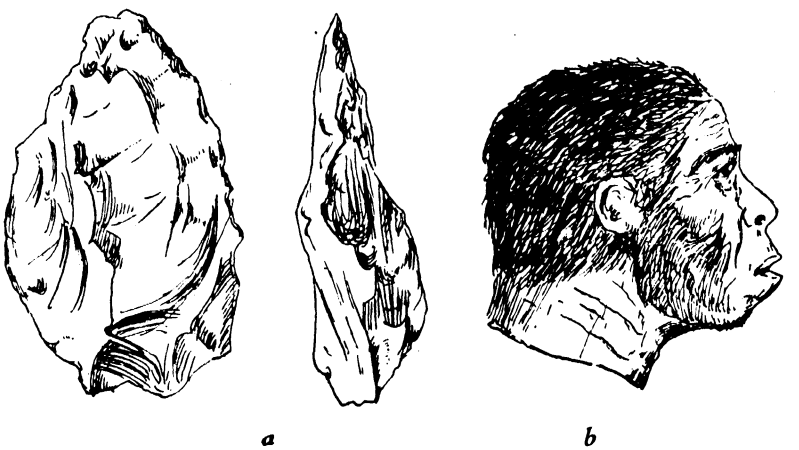


Fig. 104. Piltdown man and his stone tools.
a, two views of an implement found associated with the fossil remains. *b*, restoration of the head; (After Dowson).

Now, while the skull is distinctly modern and may do credit even to a present-day Englishman, the jaw is typically ape-like (Fig. 104*b*). Thus, some conclude that the ape-like Piltdown jaw became associated with the wrong skull during the course of its journey down-stream,[1] just as the aforementioned gentleman picked up the wrong suit-case on his trip. Indeed, in the opinion of some eminent scientists, it is quite uncertain whether the two belong to the same individual or even to the same genus, for the uncouth jaw seems to ill befit the refined skull.

From the same bed wherein the remains of Piltdown man were found, were recovered an apparently worked piece of bone and some crudelyshaped stone implements (Fig. 104 *a*) which cannot be confidently assigned to any one of the Palaeolithic

culturés. Indeed in the opinion of the French scientist Breuil, the 'shaping' of the bone is not due to man, but is the result of gnawing by a wild animal, probably a beaver, whose remains are also found at the site.

A characteristic feature of the Piltdown skull is its thickness, which is as much as 12 mm., compared to about 7 mm. in the Neanderthal man and about 6 mm. in modern man. Other features are the high forehead and the absence of well-developed brow-ridges which are so characteristic of the primitive races already described, but which are barely perceptible in modern man. To these characteristics may be added a relatively flat nose. According to some, the brain capacity was about only 1100 cc., which is much less than that of the Neanderthal man (p. 240). But since the restoration of the skull is based only upon fragments, this figure is not accepted by all; indeed according to the investigations carried out by Keith, the figure should be as high as 1500 cc. which is greater than the average brain of modern man !

The Piltdown jaw and teeth are, however, typically ape-like in structure. The canines project well above the level of the other teeth, which shows their ape-like character. The molars are, similarly, of simian affinities.

From the foregoing analysis it would appear best to keep an open mind, for the Piltdown jaw may, after all, turn out to be the jaw of one of the apes which it resembles a great deal. Indeed, the American palaeontologist Miller, is definitely of the view that the jaw belongs to a chimpanzee, and has even named it *Pan vetus*, *Pan* being the generic name for the chimpanzee. Marston is less definite as to the particular affinities of the jaw, but he, too, is convinced that it belongs to an ape, and not to the human type of skull.

The age of the Piltdown deposit was long regarded as early Pleistocene, on account of some members of the contained fauna. But today these fossils are generally regarded as *derived*[1] from an

1. During its course, a stream may pass over, or a sea beat against, ancient geological formations from which fossils may be washed out and get inter-mixed with remains of contemporary life. When, at a later date, the strata deposited by the stream or the sea become exposed, they sometimes contain a puzzling admixture of fossils of more than one age. The geologically older fossils in such an assemblage are known as *derived fossils*. In the present case, the associated fossils on the basis of which an older age was assigned to the Piltdown skull, are considered as having been derived from an earlier formation by re-deposition.

earlier deposit. Quite recently, estimates have been made of the flourine content of the human fossils and other bones from Piltdown. The result suggests that they are of Upper Pleistocene age or even younger. In other words, the Piltdown fossils should be regarded as unreliable for determination of age and we must await fresh evidence for authentic dating.

Homo heidelbergensis or Heidelberg Man

Another very interesting type, to which the name Heidelberg man has been given, was found at Mauer near Heidelberg, Germany, in river sands which belong to the earlier part of the Great Ice Age.

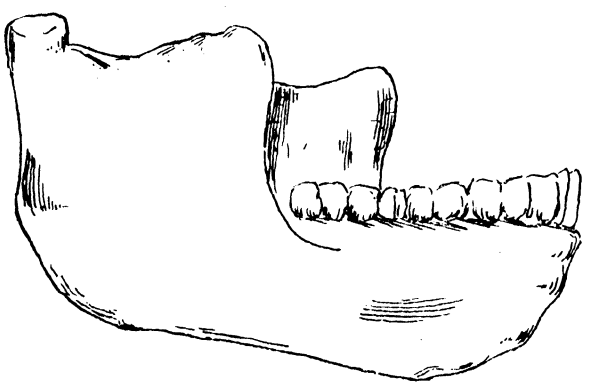


Fig. 105. Jaw of Heidelberg man, *Homo heidelbergensis*. While the jaw is massive as in the apes, the teeth are, on the whole, like those of man. Note that the canines are flush with the general level of the row of teeth, not rising above it as in the apes.

This fossil is represented by a single jaw which, however, is very well preserved (Fig.105). Like the ape-man of Java, Heidelberg man shows an admixture of ape and human characteristics. The jaw-bone itself is massive like that of an ape, and lacks a chin, a prominent chin being characteristic only of modern *Homo sapiens* and his early representatives (Fig. 108). But the teeth which fit the jaw, are unmistakably human in type. Furthermore, if you look at the molar tooth of an anthropoid ape, you will see that its crown is composed of five well-defined prominences or cusps. If, on the other hand, you examine a human

molar (except the first molar) you will notice that while four of these cusps are fairly prominent, the fifth is usually much subdued and, in rare cases, may even be absent. It is noteworthy that in Heidelberg man also the fifth prominence is much reduced—a condition similar to that found in the modern human races. Futhermore (and this is in some respects as important as the structure of the molar), the canine teeth, which in the apes, including the most highly evolved among them, rise above the general level of the teeth, are flush with it, as in modern man.

It may be said that in those of his characteristics which are ape-like, *Homo heidelbergensis* much resembles the living gibbon. In view of these differences in structure between Heidelberg man and modern man, the distinctive name *Palaeoanthropus* has been given to him by the Italian scientist Bonarelli. On the other hand, anatomists like Weidenreich, have considered the Heidelberg man as closely related to, though larger in size than, Neanderthal man. There is, in our opinion, no doubt about the gap which separates Heidelberg man from modern man, and since we have only a jaw-bone for evidence, it is desirable, in the interest of caution, to class Heidelberg man separately for the present.

We are uncertain whether the Heidelberg man possessed the capacity of speech, but if he did, it must have been very rudimentary because there is little space left for the free movement of the tongue owing to encroachment by bony tissue, a condition found in the apes.

The detailed structure of the teeth is sufficiently distinct from that of modern man to preclude the possibility of the Heidelberg man being his direct progenitor. For, while the teeth of modern man are suitable for a mixed flesh and vegetable diet, those of the Heidelberg man seem much more adapted to a herbivorous diet. Therefore, it would appear that the Heidelberg man lies on a side-branch of the line of descent to modern man and may be regarded as a divergent specialisation.

Along with the fossil jaw of the Heidelberg man were remains of the Interglacial forest elephant, *Elephas antiquus*; of a horse intermediate between the Pliocene form, *Equus stentonius* and the modern horse, *Equus caballus;* of *Rhinoceros etruscus* and of the giant deer and many other species. Remains of a lion were also found as elsewhere in the Ice Age deposits of Europe. This is

noteworthy, since no lions are found anywhere in Europe today. The evidence of the associated fossils indicates that the Heidelberg man lived during the earlier part of the Great Ice Age, probably in a mild phase close to the Mindel or Second Glaciation which gives him an antiquity of about 450,000 years.

It should also be mentioned that, though the Heidelberg man must have used stone implements, none have been found along with his remains. There are, however, fragments of bone which Vöelcker has interpreted as having been shaped and used by man.

Homo neanderthalensis or Neanderthal Man

It is perhaps not unexpected that during the early and middle parts of the Great Ice Age, with which we have so far been mainly concerned, human remains should be scarce. This was a time when primitive man still lived in forests or in the open country without even a temporary abode. No wonder then that our acquaintance with the Heidelberg man, the Java ape-man and his earlier relative, *Homo modjokertensis* (and even the Peking man), is based almost entirely upon incomplete and isolated portions of skeletons. Indeed, even at the commencement of the Third Interglacial episode when Neanderthal man first appeared, the position was still much the same. And it was not till Mousterian times that man took to the caves because of the intense cold of the beginning of the Fourth or Last Glaciation. It is then that for the first time, we come across skeletons of man in some abundance. They represent the Neanderthal race, which we shall now discuss.

It is known that the distribution of the Neanderthal race was widespread. We need not go into details of each find, but some of the more important ones may be mentioned. The first correctly interpreted discovery of fossil remains of Neanderthal man, a skull-cap and leg bones, which gave the race its distinctive name, was made in 1856 at Neanderthal, between Düsseldorf and Elberfeld, in West Germany. Prior to this, in 1848, a skull-cap, later assigned to the same race, had been discovered in the Forbes quarry at Gibraltar. At that time the full significance of the find was not realised, even though a new type of humanity had been brought to light. However, numerous other discoveries of Neanderthal man soon followed in succession, for example

at La Naulette in France (1866), at Spy in the Namur Province of Belgium (1866) and at Krapina in Yugoslavia (1899). In addition to these, nearly complete skeletons of Neanderthal man were found at La Chapelle-aux-Saints (1908), Le Moustier (1908), La Ferrassie (1908) and at La Quina (1911), in different parts of France, besides two skulls found at Saccopastore in Italy (1929). There are also many other finds. It will thus be seen that our knowledge of the Neanderthal race and its widespread distribution is based upon ample and reliable evidence.

Characteristics ; The Chin appears for the First Time

The skull of Neanderthal man was of the dolichocephalic type, that is, rather long in proportion to its width (Fig. 106).

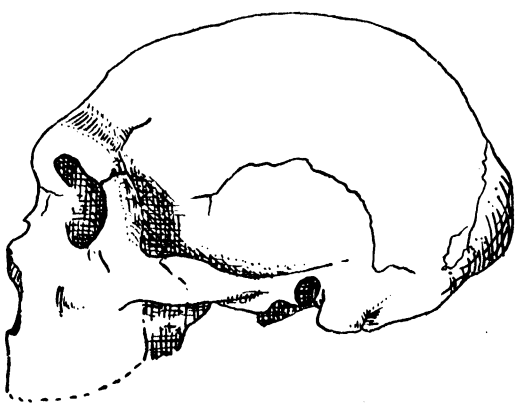


Fig. 106. Skull of one of the Neanderthal men from Italy. Note its elongated (dolichocephalic) and flattened character and prominent brow-ridges. The Neanderthal individuals possessed massive heads and large brains in spite of their simian appearance. (After Blanc)

It was vertically depressed and was characterised by massive, bony projections in the region of the orbits (brow-ridges) and a low receding forehead. *The face exceeded in dimensions the largest face known in any human race*, and projected forward as in the apes. Compared to the size of the skull, a large face is a primitive character. In this connection we may draw the reader's attention to Fig. 107 in which (following Boule) the skull of the distinguished American naturalist Cope is superimposed upon that of a Neanderthal skull for comparison. It will be seen that while

their brains are almost identical in size, the face of Cope is smaller by far.

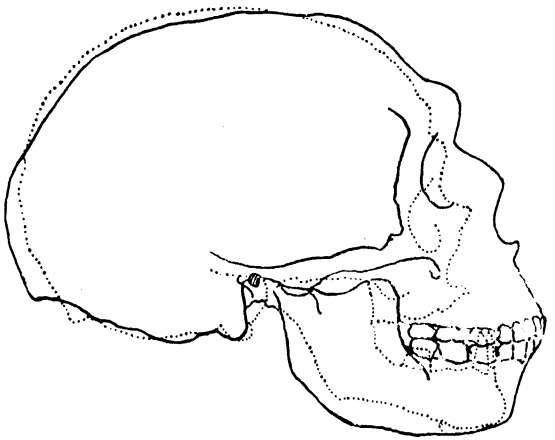


Fig. 107. Outline of the skull of the celebrated naturalist Cope (in dotted line) superimposed upon that of Neanderthal man, for comparison of relative brain capacities and size of the face. (After Boule)

A feature of some importance and interest is the presence of an incipient chin in some individuals of Neanderthal man, *our first acquaintance with this refined part of anatomy in the history of the human race.* The chin has been recognised as an attribute of *Homo sapiens* not possessed by any of the fossil races so far considered. Its general evolution and more particularly the progressive stages of development are represented in Fig. 108. It is interesting to note that those very characters, like a prominent chin, a high forehead, a thin skull, which are considered as attributes of modern man, are less prominent in the apes and in primitive fossil man.

The Neanderthalers possessed large and powerful jaws, into which were fitted teeth of correspondingly large size. But in pattern and structure their teeth were like ours and not like those of the apes, or even of the Java ape-man. However, on the whole, they approached nearer to the teeth of the more primitive modern human races, like the Australian bushman, rather than to those of the civilised races.

The brain of Neanderthal man was surprisingly large. One of the skulls, that from La Chapelle-aux-Saints, possessed a

brain capacity of as much as 1600 cc., larger than the average brain of the modern civilised races. The average size of the brain in the Neanderthal race was, however, no more than

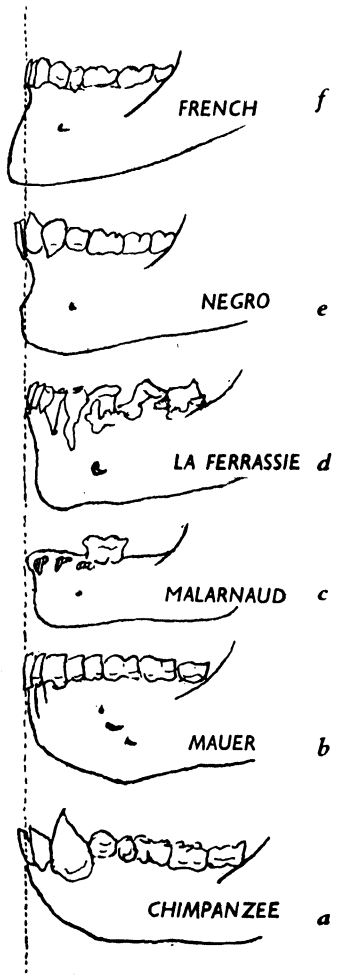
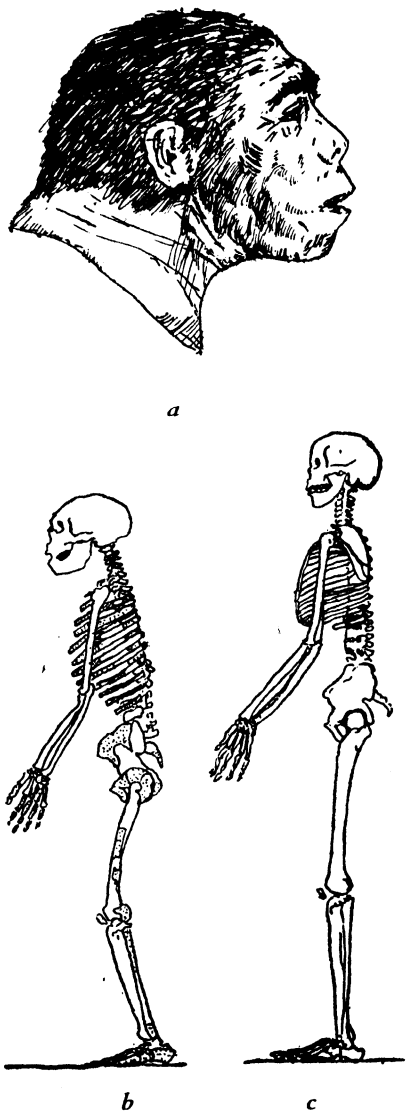


Fig. 108. Series of lower jaws of various fossil men and of the chimpanzee (in ascending order), illustrating the evolution of the chin.
a, chimpanzee ; *b*, Heidelberg jaw without any semblance of chin; *c*, Neanderthal jaw showing first appearance of chin in man; *d*, another Neanderthal jaw with a slightly more prominent chin; *e*, Negro jaw with well-developed chin though not so prominent as in the more advanced modern races, for example *f*, the Aryans. (After Boule)

1400 cc., for individuals with smaller brains measuring only 1300 cc., are also known.

While the brain was no doubt large, especially considering the general physical attributes of this man, which were in many



ways ape-like (Fig. 109*a*), its detailed structure was comparatively simple. The frontal part of the brain, which is the intellectual region, was but poorly developed, so that the intelligence of Neanderthal man, in spite of his large brain, was certainly inferior to that of modern man.

If we compare the entire skeleton of Neanderthal man (Fig. 109*b*) with that of modern man (Fig. 109*c*) our attention is at once directed to a number of striking peculiarities. In the first place, this fossil man was not much more than 5 feet in height, nor did he stand erect like modern man, but retained a somewhat bent posture. This posture became further accentuated by his much curved thigh bones, which were, incidentally, rather long in proportion to the total length of the leg (Fig. 109*b*). Also, his ribs were much stronger than those of the living races and he must, therefore, have been of robust appearance.

Fig. 109. Complete skeletons of Neanderthal man and modern man and restoration of the Neanderthal head.
a, restoration of head; *b*, skeleton of Neanderthal man; *c*, skeleton of primitive modern man (Australian) for comparison. (*b* and *c*, after Boule)

In modern man, the spine forms a graceful double curve, with one concavity in the upper (neck) region and another above the lower spinal extremity. In the Neanderthal man, on the contrary, there seems to be practically a single convex sweep of the spine, giving the impression of a hunchback (109*b*), the two subsidiary curvatures being barely perceptible. That the upper part of the body was bent forward is also proved by the insertion of the spine at a point more towards the back of the skull, rather than at its base as in living man, so that the head protruded forwards.

A point of great interest is the structure of the Neanderthal foot which, in contrast to ours, rested edge-wise on the ground, like that of an infant. It is well-known that the apes also do not rest their feet flat upon the ground but edge-wise like the young of the human species who, moreover, start by walking on all fours like the apes, and only gradually assume the erect posture.

Origin, Culture and Antiquity

There are divergent views as regards the origin of the Neanderthal race. According to some, it represents an independent offshoot of the main human stem; according to others, an earlier stage—the Heidelberg race—intervened before the true Neanderthalers came into existence. Furthermore, certain authorities believe that the Neanderthal race arose from the *Pithecanthropus* (Java ape-man) stock and itself gave rise to *Homo sapiens*, the species to which we belong.

The culture of the Neanderthalers was of the well-known Mousterian type. They made various implements including points, scrapers and hand-axes. It is, however, possible that they had only spear-heads and axes for defensive weapons, which were scarcely a match for the bows and arrows of the Cro-Magnons (see p. 247), who thus easily defeated them in combat. The Neanderthalers were the first in Europe to use bone for making implements, and the first to practise burial. They were also practically the first to seek the shelter of caves, though many open living-sites also existed.

It is not unlikely that we have inherited some of our habits from the Neanderthal men or from our other primitive ancestors. As examples may be cited: the taste for 'high' meat (to put

it mildly) which some races still cherish; for insect larvae, ants and stale eggs which the Chinese and other mongoloids specialise in; for 'high' fish (*ngape*) by which the Burmese swear.

The Neanderthal race appeared in the Third Interglacial stage about 150,000 years ago and survived for about 70,000 years.

Although the Fourth or Last Glaciation was geographically not so widespread, yet it was one of intense cold, as conditions similar to those of the Arctic tundra prevailed in Europe. However, it was certainly not the cold which led to the decline of the Neanderthalers. They were finally ousted from Europe by the more intelligent and more virile Cro-Magnons, who invaded Europe from Asia in a mild oscillation of the climate after the first phase of the Last Glaciation, between 80,000 and 100,000 years ago. One human race ousting another is thus not a new story.

Homo rhodesiensis or Rhodesian man : An African Relative of the European Neanderthal Race

Though Rhodesian man is of African origin, we propose to deal with him here on account of his apparent close affinity with

Fig. 110. Skull of the Rhodesian man, *Homo rhodesiensis*, seen in profile. Note the prominent brow-ridges.

the European Neanderthalers. The discovery of the Rhodesian man is, in some ways, of unique interest as he represents, firstly, a racial link between Western Europe and the dark continent and, secondly, he is an archaic type who may have survived into comparatively recent times, if certain evidence were believed.

The remains of the Rhodesian man were found in 1921 in a cave in Northern Rhodesia, where they were unearthed during the course of mining operations in the famous Broken Hill mine. Along with the human bone remains, stone implements similar to those used by the modern races native to the soil, and remains of other recent animals were recovered, none of the bones being mineralised in the real sense of the term.

The human remains are, in some respects, more remarkable than those of any of the races already dealt with. The well-preserved skull without the lower jaw arrests attention on account of the anomalies it presents. A glance at Fig. 110 immediately suggests the primitive race of *Homo neanderthalensis*. The skull from Rhodesia is even more ape-like, if anything, in appearance than the Neanderthal skulls. Except for a modern type of brain-case, he possesses the same well-developed ridges above the eye-sockets, the same receding forehead, and even the same human type of dentition, as the Neanderthal man. And yet the skull is scarcely mineralised, which suggests that this man must have become extinct comparatively recently. The Neanderthal man, it may be recalled, is ancient, and his remains have always been found thoroughly fossilised. Although the question is rather speculative, it is not unlikely that this archaic type from Rhodesia is a descendant of the Neanderthal race, which persisted in Africa, while the Neanderthalers became extinct on the continent of Europe. But if the Rhodesian man were found alive, he would come before us, not crouching like the Neanderthal man, but standing erect, for the structure of the basal part of his skull strongly indicates that, unlike the Neanderthal man, he had a straight neck (Fig. 111), which proves that he stood perfectly erect. If the Rhodesian man is a descendant of the Neanderthal man, the former must have acquired the erect posture by evolution.

Fig. 111. Restoration of the head of Rhodesian man.

Before we proceed, we might give the views of some noted authorities concerning the genealogical position of the Rhodesian man. According to Woodward, "The Rhodesian man may ..... revive the idea that Neanderthal man is truly an ancestor of *Homo sapiens*, for *Homo rhodesiensis* retains an almost Neanderthal face in association with a more modern brain-case and an up-to-date skeleton. He may prove to be the next grade after Neanderthal in the ascending series." On the other hand, Boule is inclined to the view that the Rhodesian man, the Neanderthal man and the Australian bushman are blood brothers (so to speak) who went different ways, one to Africa another to Europe and the third to Australia. Where the forefathers of the race originated no one knows for certain though it may have been in South-East Asia.

Whatever may be the truth about his relationship and origin, there is no doubt that Rhodesian man has been, and still is, a puzzle to scientists.

VII. RACES OF FOSSIL *HOMO SAPIENS* IN EUROPE

Cro-Magnon Man

We shall now deal with certain races of fossil men that do not differ in any essential respect from modern man or *Homo sapiens*, represented today by the various races, including the most highly civilised and the most primitive of them, whether Black, White, Brown or Yellow.

We find that, in Europe, the Neanderthal race is followed suddenly and abruptly by a much superior race, the Aurignacians, (from Aurignac in France), the carriers of the Upper Palaeolithic culture. The Aurignacian period of archaeologists marks the commencement of the Fourth (and last) Glaciation of the Ice Age. During the whole of the Aurignacian period, man in Europe must have thus faced extreme rigours of climate.

The question may now be asked, Where did this race come from ? It is obvious that it could not have arisen all of a sudden, so it must have existed somewhere in earlier times. And the discoveries, though all too rare, of fossil remains in the same localities where the Neanderthal fossils have been met with prove the existence, contemporaneously with the un-

couth Neanderthal man, of the more advanced *Homo sapiens*, represented by a race to which the name Cro-Magnon has been given. This association is not at all surprising for we find today, in the atomic age, really primitive races living together with the highest representatives of *Homo sapiens*, though of course, the evolutionary gap between Cro-Magnon man and Neanderthal man is much greater than that between, say, the Proto-Dravidian and the Indian Aryan or between the Australian aboriginal and the European.

There is evidence to support the view that *Homo sapiens*, as we know him today, has existed since at least the early Upper Pleistocene times, if not in Europe, then in other regions, and must *ipso facto* have originated much earlier, though when exactly we cannot at present tell. It is not unlikely that he was of Asian origin and migrated to Europe under circumstances not quite known. In this context it should be remembered that the Swanscombe man, of Middle Pleistocene age, showed many characters of *Homo sapiens* and thus suggested that *sapiens-like men had arrived in Europe for the first time* in the Great Interglacial. But they were replaced by Neanderthal man subsequently. In the Last Glaciation, it had become the latter's turn to be ousted by a truly superior race, the *Cro-Magnons, who re-entered Europe for the second time*. The presence of *Homo sapiens* in the Middle Pleistocene, would give an antiquity of 250,000 years to the *Homo sapiens* stock. And if the evidence of the Kanam jaw from East Africa were relied upon, it would take us back to the Lower Pleistocene which would mean that the roots of the *Homo sapiens* stock lie buried somewhere in the Pliocene (Tertiary era). However doubt still remains concerning these discoveries for either their geological age or their systematic position is uncertain on account of insufficient organic remains. But it can be stated that authentic remains of *Homo sapiens* date back about 100,000 years.

Since the Cro-Magnon man hardly differs from modern man, it is scarcely necessary to describe him in detail. However, attention may be drawn to certain features which are more or less striking.

Numerous fossils of the Cro-Magnon race have been discovered, including many complete skeletons. The most notable of these are a family (we presume it was one) consisting of five

individuals—three men, a woman and an unborn child, all from the Cro-Magnon rock-shelter. This baby Cro-Magnon still lay in the position of its mother's womb, and thus first saw the light of day (in every sense of the term) by the stroke of the geologist's hammer.

Fig. 112. Restoration of the head of Cro-magnon man, one of the early authentic representatives of *Homo sapiens* or modern man. His brain capacity was equal to that of modern man and he belonged to a tall race with refined features.

The Cro-Magnons were distinguished by their tall stature, attaining a height of almost 6 feet. They possessed rather high, elongated or dolichocephalic skulls of large brain capacity, measuring 1600 cc., though a broader or sub-brachycephalic (Predmost) type named after that locality is also known. Therefore they must have attained a high degree of intelligence. The rather flat face had prominent cheek bones, and was relieved by a fine, longish nose that must have contrasted well with the comparatively narrow head. On the whole, therefore, this race seems to have resembled the modern American Indian a great deal (Fig. 112). Cro-Magnon man was a keen hunter and fisherman, and lived not only in caves but probably also in huts. He knew the use of bows and arrows. Cro-Magnon women of 30,000 years or so ago must have been as vain as the modern damsels, for remains of necklaces and other ornaments have been found in the caves.

The Cro-Magnons became the racial substratum in which the population of Europe developed in the course of the

later Ice Age. Many admixtures occurred, including probably some Neanderthal blood. But all these variants were carriers of the Upper Palaeolithic culture.

The Chancelade Man

An interesting variant of Upper Palaeolithic man has been named the Chancelade race. Fossils of this race were first discovered in 1872, at Laugerie-Bassé in France, by the anthropo-

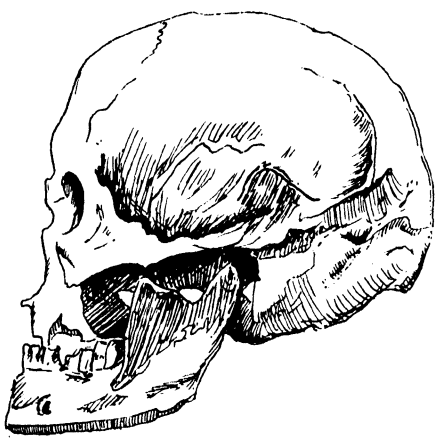


Fig. 113. Skull of Chancelade man, a late Palaeolithic representative of *Homo sapiens*. (After Testut)

logist Masénat. Another similar discovery was made in 1888 near Chancelade in the Dordogne district of France, in rocks of Magdalenian age, while complete skeletons were found at Obercassel near Bonn, in Germany. In addition to the above, several other less known discoveries have been made.

Men of the Chancelade race were of massive build. Though short in stature, attaining a height of just over 5 ft., they possessed larger brains even than living *Homo sapiens*. Their faces were on the whole broad and large. They had high foreheads, prominent cheek-bones and chins (Fig. 113); their molars were, however, of primitive design. In nearly all these characteristics the Chancelade race resembles the modern Eskimos, who in view of their close association with the reindeer are true reflections of men of the Reindeer Age. It has even

been suggested that the Eskimos are the descendants of the Chancelades themselves, but this view is no longer held by experts. It is thought that the resemblances are not real but probably due to convergent evolution under the influence of similar environments.

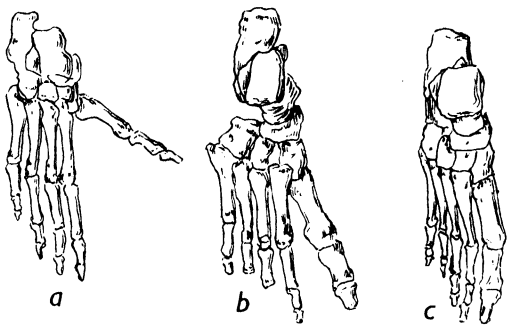


Fig. 114. Skeletons of foot of the Chancelade man, the chimpanzee and modern man.
a, chimpanzee; *b*, Chancelade man; *c*, modern man. Note that in the chimpanzee the great toe is well separated from the remaining toes, while in the Chancelade man it is less apart though much more so than in modern man. (After Testut)

The limb-bones of the Chancelades were massive and of negroid proportions. Even more noteworthy were the feet, which in some respects resembled those of the Neanderthalers. The position of the big toe was intermediate between that obtaining in the chimpanzee and in modern man (Fig. 114), so that the Chancelade man could probably climb with alacrity and could also grasp branches, etc. with his feet, without much difficulty.

Fig. 115. Mode of burial adopted by tribes in Natal, South Africa and by some of the Upper Palaeolithic *Homo sapiens*. (After Nelson)

Opinions thus differ as to the exact relationships of the Chancelade man, but there appear to be many points of affinity between him and the Cro-Magnon and Grimaldi men even though there are considerable differences of stature and facial proportions.

The mode of burial of Upper Palaeolithic man is often intriguing. It suggests that the corpses were probably tightly folded up and then effectively tied so that the legs pressed

closely against the chest, somewhat after the custom of the modern Eskimos and South African races (Fig. 115). The bones are accompanied by numerous implements and are often found covered with red ochre which suggests that the body, or the skeleton stripped of its flesh, received some kind of ceremonial treatment before burial. This reminds us of St. Protasus and St. Gervaise who have been mentioned in the Introduction.

The Grimaldi Man; Representatives of a Negroid Race in Europe

A human race of great interest is that to which the name Grimaldi has been given, so called after the village of that name on the borders of France and Italy. The skeletons were found in cave deposits. One of these caves wherein the fossils of the Grimaldi race occurred is known as the *Grotte des Enfants* or Childrens' cave, so named because fossils of two children were found in them.

The manner in which the Grimaldi fossils were found is noteworthy, and had it not been for the fact that their excavation was in the hands of an expert, our conclusions regarding their age might well have been widely off the mark. There is a total thickness of about 30 feet of deposits in the *Grotte des Enfants*, in which remains of two distinct races were found fossilised. Though the Grimaldi fossils were found at a depth of about 25 feet in a layer corresponding to the Mousterian period of the Lower Palaeolithic, it fortunately came to light that they were actually buried in a man-made pit, so that they properly date from a more recent period, the Aurignacian. It was, therefore, very fortunate that the fact of the (artificial) burial of these Grimaldi men was recognised. Incidentally, this illustrates the importance of the stricter definition of the term 'fossil' on which we laid emphasis earlier (p. 36). Within the same cave were found remains of the Cro-Magnon race, which has already been dealt with.

The Grimaldi skeletons, two in number, were found resting in a crouching attitude (Fig. 116). According to a French scientist, one of these possesses a worn-out jaw and is believed to represent an old woman, and the other a young

boy in the middle teens. The two may well represent members of a single family—perhaps mother and son—each guarding the other within the loneliness of their common grave !

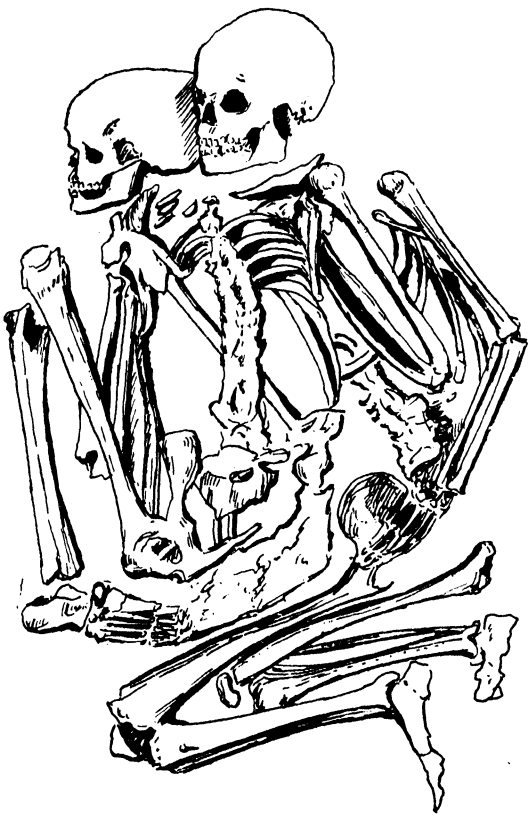


Fig. 116. Skeletons (male and female) of the negroid Grimaldi race, found buried together. (After Verneau)

In fairness to the 'old' woman from Grimaldi it may be stated that the age of the lady in question (based upon the worn-out condition of her jaw) is in dispute. And as members of the fair sex are sensitive on this point to the extent that at 18 their age often becomes stationary and certainly after twenty-five it begins to vary in the recessive direction (and why not ?), we should like to undo an injustice.

According to the well-known and gallant British palaeontologist Elliot Smith, the jaw of the fossil woman from Grimaldi gives a misleading idea of her age. The evidence upon which this conclusion is based is as follows : the human skull or brain-box consists of a number of separate bones, the junction lines of these bones being known as sutures. As the result of examina-

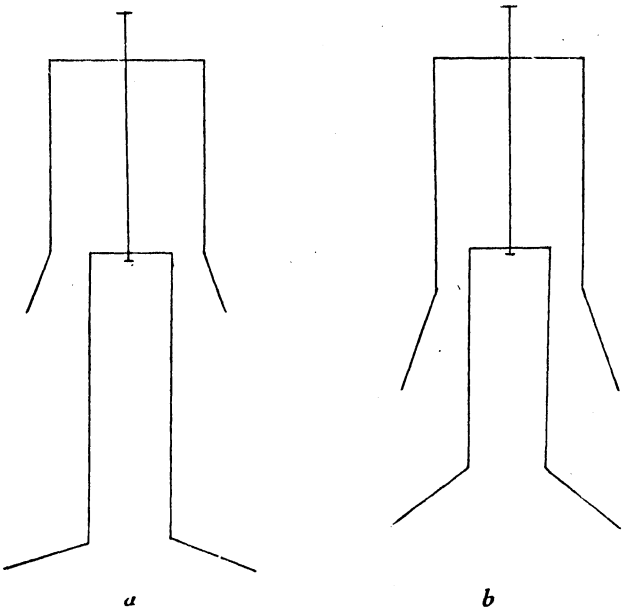


Fig. 117. Proportions of arms and legs in the Primates.
a, man and *b*, chimpanzee. In the orang-utan, the arms are even longer in proportion to the legs or hind-limbs, than in the chimpanzee. (After Wilder)

tion of a very large number of skulls, it has been established that these sutures remain open (so that the individual bones are separate) till about the age of 30 in man and woman, *whatever be their race*, and join up in later years. Now it is seen that in the skull of the woman from the *Grotte des Enfants*, these sutures are still open, which establishes that she was young and probably under thirty.

An interesting point is that in their general appearance and in the structure of the skull, legs, arms and even the pelvis of the female, the two Grimaldi skeletons show features which appear

to be negroid. Attention may be drawn to the fact that a narrow skull and flattened face, combined with a massive jaw and a comparatively feeble chin, are characteristic of the negroids and indicate primitive features. It is perhaps not so commonly known that the proportions of the thigh-bone to the leg as a whole and of the forearm to the total length of the arm, are somewhat different in negroids from those found in others. The thigh-bone in the negroids is disproportionately short when compared to the leg, and the forearm is much longer than the arm as a whole. Such are the proportions met with in the Grimaldi fossils, which seem to favour their negroid affinity. Even more striking are of course the differences in these proportions in man and the anthropoid apes and these are indicated in Fig. 117.

UPPER PALAEOLITHIC SCULPTURE AND ART

The Upper Palaeolithic races of Europe had attained much skill and proficiency in sculpture and, of course, also in painting. Their art is often of a dynamic and expressive character. Among the most remarkable qualities was their ability to draw figures of animals and to paint them. They used tools made of bone and stone for engraving and scraping, and utilised coloured earths for paints. These paints have not faded much during at least 25,000 years.

Although we are familiar with the art of Upper Palaeolithic man in Western Europe, (paintings from the French province of Dordogne and the caves near Altamira in northern Spain being particularly well known) the chance discovery of the cave of Lascana, near Montignac in south central France, as recently as 1940, is of the greatest importance. It is of interest to record that this was found by schoolboys who were chasing rabbits that had made their home in the caves wherein Upper Palaeolithic man had lived, and which had since been covered by debris. Following the rabbits inside the caves, they found a wonderful picture-gallery of Stone Age art, undisturbed through the lapse of years.

CHAPTER XI

EPILOGUE

IN conclusion we may enquire, What is the verdict of evolution ? In the foregoing pages, we have taken pains to impress that change is the law of nature, irrespective of whether such change implies progress or the reverse, and this inevitable law is applicable not only to the organic, but also to the inorganic world. The molecule breaks down into atoms, the atom into protons, neutrons and electrons, each representing an infinitesimal unit of energy so that, in truth, matter and energy are one and the same thing. By a reverse process—that of building up—atoms and molecules are reproduced, and, depending upon varying conditions, different types of matter come into existence. Carbon under certain conditions appears in the form of coal, whilst under other conditions it gives rise to diamonds. Even the alchemist's dreams have come true for certain radioactive element can be interchanged by nuclear reactions. In short, the processes of building up and disintegration are constantly going on. These changes, however, are not 'evolution'. In the organic world changes also occur. They are in part due to the impact of the environment and to competition between individuals of the same species, and thus are due to causes acting from without; in part, however, they are due to forces working within the living organism, such as the urge to perpetuate the race, the desire for food. All these are known to produce various changes in the structure of the organism which are summed up under the term Evolution. It is the verdict of these changes—the verdict of Evolution—with which we are here primarily concerned.

One of the most important facts that has come to our notice, and one which we hope our readers fully appreciate, is that many species, genera, families and, indeed, whole groups comprising thousands of different types of living beings, have become entirely extinct, even though they often made, on the eve of their extinction, a glorious but vain attempt to survive, having realised too late the error of their ways. (In making this statement, we do not, of course, intend to imply any conscious reasoning).

Thus perished the Graptolites[1] towards the close of the Silurian period of geological history, after having survived for about 180,000,000 years; thus became extinct the great group of the Trilobites[1] in Permian times, after a lapse of 300,000,000 years (or more) and thus also the Cephalopods[1] met their doom towards the close of the Cretaceous era, having flourished through the time interval of 350,000,000 years.

On the other hand, the genus *Lingula*, one of the sea animals possessing a shell, has persisted to this day, almost since the dawn of life on the globe, through the unprecedented time interval of about 500,000,000 years. The secret of its success appears to be the simplicity of its structure and its 'modesty', for it is content to live in ordinary sandy mud in the sea, a *lebensraum* which has always been available. So the race of man has much to learn from this mute and humble sea-shell of dull grey and unassuming hue, holding communion only with the sea or the sands upon its shores. And if one were to apply these conclusions to the human race, one would say that the success of various races, communities, etc., is often due to specialising in the exploitation of certain environments by far-going adaptation. But this means inevitably that such organisms become unsuited to life in different environments and therefore often become the victims of their own over-specialisation. But others owe their survival to the retention of adaptability to physical environment, to fortune and misfortune. It is well-known how, entirely because of their adaptability, members of thrifty communities, even multi-millionaires, survive the vagaries of fortune when they have been reduced to utter penury. And it was not merely numbers that brought about the annihilation of the German Army in the last war, but the rigidity and unadaptability of the Nazi war-machine and political system. Furthermore, if the highly specialised atomic bomb contributed much to the breakdown of the Japanese, it is a fallacy, we believe, that specialised methods can lead to permanent dominance. And, after all, there is no weapon which is not double-edged. Therefore, if any system is to prove a success and survive, it should be mobile, adaptable to changing conditions, and simple.

[1]These are various groups of invertebrates which played dominant roles in the life of the periods during which they lived.

The keynote of survival, the great lesson that Evolution has taught us, is Generalisation (not Specialisation) and Adaptability.

To continue. Amongst the vertebrates, there died out, after brief but glorious episodes, the Dinosaurs of the Mesozoic, the varied elephants of the Tertiary era (with the modern *hathi* surviving), some with four tusks (Tetrabelodon), others with flattened or shovel-shaped tusks (Platybelodon) and many other representatives of this family, too numerous to name. It is of interest to note that the large-scale extermination of the Tertiary vertebrates was due to the onset of cold conditions with the advent of the Great Ice Age in certain parts of the world, the change being so rapid that many of these animals found adaptation impossible.

But what of the human race ? Whither is it bound ? If we listen to the verdict of evolution, we can draw but one conclusion—that unless a conscious attempt is made to prevent it, EXTINCTION IS THE FINAL DESTINY OF THE HUMAN RACE. Indeed, have not already several of the human races suffered extinction, to wit—the race of the Java ape-man, of the Heidelberg man and the Neanderthal race ? Is it not the turn of the race of modern man, the all knowing, the all-wise and almost the almighty ? Can we evade this doom ? Let us face the question.

In general, it may be stated from past experience of extinct races that annihilation follows specialisation in the physical make-up and subservience to environment, which prevents easy reaction to changes of various types and adaptation to them. Now, of all the organic features we believe that the human brain has become the most highly specialised, and may be ultimately responsible for the extinction of the human race, unless we take advantage of it, and consciously resolve (a capacity which none of the extinct races of vertebrates or invertebrates possessed) not to use the death-dealing discoveries for our own extermination. This hope is seemingly too pious for the tempo of modern life and humanity. But this is our only safeguard. Thus that very factor the possession of which alone would entitle us to almost eternal existence, may be the very cause of our extermination, unless we pause, think and act.

In the tempo of modern life it is difficult to assess which course, which direction, the affairs of man will take. But the omens portend no good. Scarcely is a war over, a war fought, we are

told by the belligerents, to make the world a fit place for angels to live in, when the mighty nations talk of more wars to bring 'peace and plenty' to the sorely stricken world. Alas, invariably, at the end of the war the angels take to their wings. The land-hunger, the unceasing quest for raising the standard of living (without raising the standard of thinking), the common desire to possess what the other has—a desire which has led to the spectacle of strange bed-fellows—often seem uppermost in the minds of men and nations, in spite of their professions to the contrary. The result is a strange and diabolical, biological phenomenon, *the organised destruction of its own species by the race of man*; a phenomenon which does not strike us as being diabolical merely because of its periodic repetition. Of all the varied races of the animal kingdom there is not a single species, except perhaps certain kinds of ants, which indulges in the pleasant pastime of the organised and preconceived destruction of its own kind. If two dogs fight, there is probably a bone or a bite involved, if two apes have a scuffle, the reasons are similar. But not so with our good friend *Homo sapiens*, or Man the Wise. He will fight upon almost any excuse, not merely for material things, not only because of natural sex inhibitions but even because of different philosophies, concepts and ideologies.

The artificiality of modern life, its complications, its multifarious needs, desires, ambitions, lead only to disturbances of the mental equilibrium and the happiness it yields is transitory and ephemeral. Indeed it appears even doubtful whether, in the mental and moral confusion that prevails today, man really considers true happiness at all essential to existence, for he seems to be very busy in the chase for excitement and more excitement. What we primarily need today is not higher standards of living (so-called) but a simpler way of life (a lesson taught by evolutionary phenomena). And we need, not the least, a higher appreciation of moral values, so that we can strike a happy balance between man's spiritual and material needs. Man has achieved the conquest of Nature; he has annihilated time, space and matter, he has the world at his feet, but he has yet to conquer himself, if he is to survive. It is high time (it may soon be too late) that we got out of this vicious circle in which we are moving today, of more needs, more industry, more competition, more jealousy, more wars, more destruction and finally more Peace—of the Grave.

Let us then pause and think awhile, whither this surging flood, not only of science but of modern civilisation is carrying us and tossing us about like foam on the crest of the sea waves. Man, the architect of his own destiny, the doyen of Nature, the master scientist, may have overshot the mark, may yet have much to learn from lesser beings than himself.

THE END

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Note. Three distinctive Palaeolithic Industries are represented in the Indian continent and Burma—the Sohan in the north-west (Potwar region of Pakistan), the Madrasian in south India and the Anyathian along the Irrawaddy valley, Burma. The Neolithic reached a high level in South India where the Microlithic (Mesolithic) is also well represented. A special phase of the Microlithic known as the Proto-Neolithic occurs along the Indus in Sind (Pakistan) and probably also in Hyderabad (India) Of particular interest and importance is the Megalithic culture of South India.