earth and reaches out to the uttermost star. Yet in all the relics of the Mesozoic time we find no certain memorials of his ancestry. His ancestors, like the ancestors of all the kindred mammals, must have been creatures so rare, so obscure, and so remote that they have left scarcely a trace amidst the abundant vestiges of the monsters that wallowed rejoicing in the steamy air and lush vegetation of the Mesozoic lagoons, or crawled or hopped or fluttered over the great river plains of that time.

CHAPTER 5

THE AGE OF MAMMALS

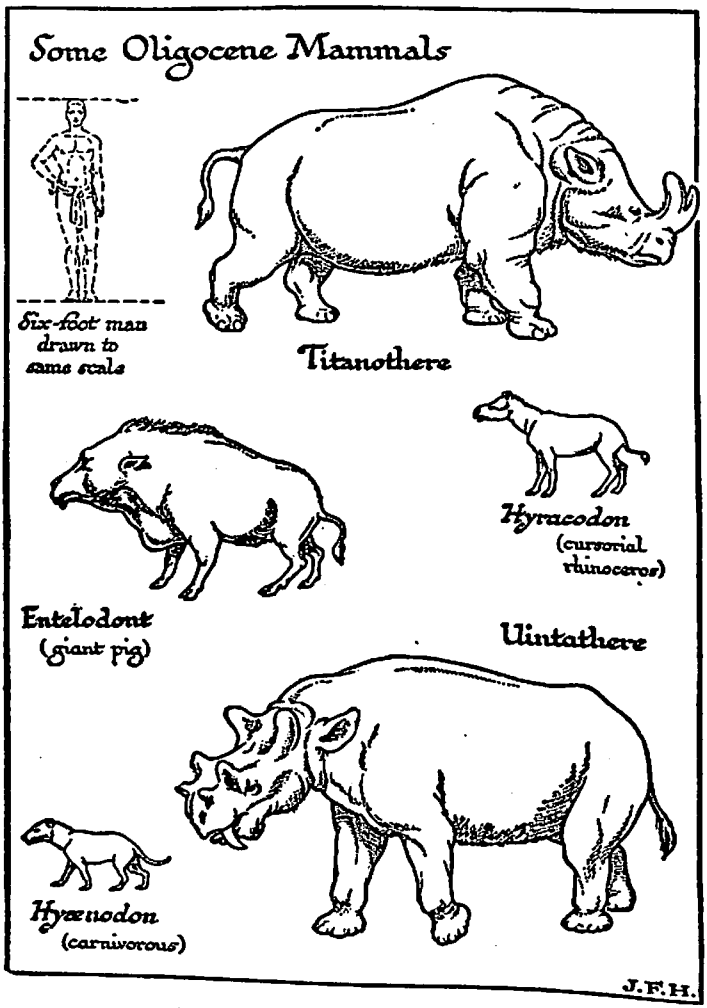
§ 1

THE third great division of the geological record sketched out in the beginning of Chapter 2, the Cenozoic, opens with a world already physically very like the world we live in to-day. Probably the day was at first still perceptibly shorter, but the scenery had become very modern in its character. Climate was, of course, undergoing, age by age, its incessant and irregular variations; lands that are temperate to-day have passed, since the Cenozoic Age began, through phases of great warmth, intense cold, and extreme dryness; there may have been variations in the landscape, but, if it altered, it altered to nothing that cannot still be paralleled to-day in some part or other of the world.

In the place of the cycads, sequoias, and strange conifers of the Mesozoic, the plant names that now appear in the lists of fossils include birch, beech, holly, tulip trees, ivy, sweet gum, bread-fruit trees. Palms were now very important. Flowers had developed concurrently with bees and butterflies. We have come to the age of flowers. Flowering plants had already been in evidence in the later levels of the Mesozoic, that is, the American Cretaceous, but now they dominated the scene altogether and everywhere. Grass was becoming a great fact in the world. Certain grasses, too, had appeared in the later Mesozoic, but only with the Cenozoic Period came grass plains and turf spreading wide over a world that was once barren stone.

The period opened with a long phase of considerable warmth; then the world cooled. In the opening of this third part of the record, this Cenozoic Period, a gigantic crumpling of the earth's crust and an upheaval of mountain ranges was in progress. The Alps, the Andes, the Himalayas, are all Cenozoic mountain

ranges; the background of an early Cenozoic scene to be typical should display an active volcano or so. It must have been an age of great earthquakes also.



Geologists make certain main divisions of the Cenozoic Period, and it will be convenient to name them here and to indicate their climate. First comes the *Eocene* (which means "dawn of recent life"), an age of exceptional warmth in the

world's history, subdivided into an older and newer Eocene; then the *Oligocene* (meaning "but little of recent life"), in which the climate was still equable. The *Miocene* (with living species still in a minority) was the great age of mountain building, and the general temperature was falling. In the *Pliocene* (more living than extinct species), climate was very much at its present phase; but with the *Pleistocene* (a great majority of living species) there set in a long period of extreme conditions—it was the Great Ice Age. Glaciers spread from the poles towards the equator, until England to the Thames was covered in ice.

Thereafter to our own time came a period of partial recovery. We may be moving now towards a warmer phase. Half a million years hence this may be a much sunnier and pleasanter world to live in than it is to-day.

§ 2

Tradition Comes into the World.

In the forests and following the grass over the Eocene plains there appeared for the first time a variety and abundance of mammals. Before we proceed to any description of these mammals, it may be well for us to note in general terms what a mammal is.

From the appearance of the vertebrated animals in the Lower Palæozoic Age, when the fish first swarmed out into the sea, there has been a steady progressive development of vertebrated creatures. A fish is a vertebrated animal that breathes by gills and can live only in water. An amphibian may be described as a fish that has added to its gill-breathing the power of breathing air with its swimming-bladder in adult life, and that has also developed limbs with five toes to them in place of the fins of a fish.

A tadpole is for a time a fish; it becomes a land creature as it develops. A reptile is a further stage in this detachment from water; it is an amphibian that is no longer amphibious; it passes through its tadpole stage—its fish stage, that is—in an egg. It can never breathe under water as a tadpole can do.

Now, a modern mammal is really a sort of reptile that has developed a peculiarly effective protective covering, hair; and that also retains its eggs in the body until they hatch so that it brings forth living young (viviparous); and even after birth it cares for them and feeds them by its mammæ for a longer or shorter period. Some reptiles, some vipers, for example,

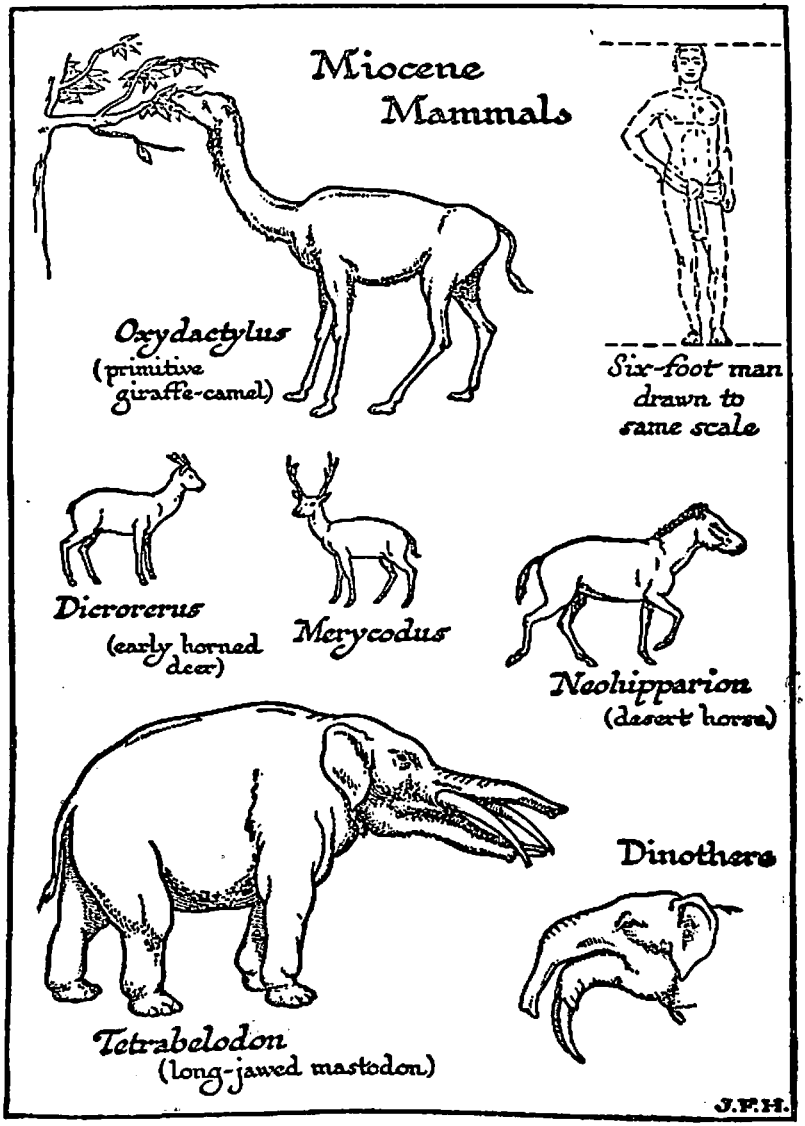
are viviparous, but none stands by its young as the real mammals do. Both the birds and the mammals, which escaped whatever destructive forces made an end of the Mesozoic reptiles, and which survived to dominate the Cenozoic world, have these two things in common—first, a far more effective protection against changes of temperature than any other variation of the reptile type ever produced, and, secondly, a peculiar care for their eggs to protect them from cold, the bird by incubation and the mammal by retention, and a disposition to look after the young for a certain period after hatching or birth. In comparison with the mammal, the ordinary reptile is altogether reckless of its offspring.

Hair was evidently the earliest distinction of the mammals from the rest of the reptiles. It is doubtful if the particular Therodont reptiles who were developing hair in the early Mesozoic were viviparous. Two mammals survive to this day which not only do not suckle their young, but which lay eggs, the *Ornithorhynchus* and the *Echidna*, and in the Eocene there were a number of allied forms. These two creatures, although they do not suckle their young, secrete a nutritive fluid from glands scattered over the skin on the belly side. But the glands are not gathered together into mammæ with nipples for suckling, as they are in other mammals. The stuff oozes out while the mother lies on her back, and the young browse upon her moist skin. They are the survivors of what was probably a much larger number and variety of small egg-laying hairy creatures, hairy reptiles, hoppers, climbers, and runners, which included the Mesozoic ancestors of all existing mammals up to and including man. At any time in some out-of-the-way deposit there may yet be a find of such "missing links."

We may put the essential facts about mammalian reproduction in another way. *The mammal is a family animal.* And the family habit involved the possibility of a new sort of continuity of experience in the world. Compare the completely closed-in life of an individual lizard with the life of even a quite lowly mammal of almost any kind. The former has no mental continuity with anything beyond itself; it is a little self-contained globe of experience that serves its purpose and ends; but the latter "picks up" from its mother, and "hands on" to its offspring.

All the mammals, except for the two genera we have named, had already before the lower Eocene Age arrived at this stage of pre-adult dependence and imitation. They were all more or less imitative in youth and capable of a certain modicum of

education; they all, as a part of their development, received a certain amount of care and example and even direction from their mother. This is as true of the hyæna and rhinoceros as



it is of the dog or man; the difference of educability is enormous, but the fact of protection and educability in the young stage is undeniable.

So far as the vertebrated animals go, these new mammals,

with their viviparous, young-protecting disposition, and these new birds, with their incubating, young-protecting disposition, introduce at the opening of the Cenozoic Period a fresh thing into the expanding story of life, namely, social association, the addition to hard and inflexible instinct of *tradition*, and the nervous organization necessary to receive tradition.

All the innovations that come into the history of life begin very humbly. The supply of blood-vessels in the swimming bladder of the mudfish in the Lower Palæozoic torrent-river, that enabled it to pull through a season of drought, would have seemed at that time, to the bodiless visitant to our planet we have already imagined, a very unimportant side fact in that ancient world of great sharks and plated fishes, sea-scorpions, and coral reefs and seaweed; but it opened the narrow way by which the land vertebrates arose to predominance. The mudfish would have seemed then a poor refugee from the too crowded and aggressive life of the sea. But once lungs were launched into the world, every line of descent that had lungs went on improving them.

So, too, in the Upper Palæozoic, the fact that some of the amphibia were losing their "amphibiousness" by a retardation of hatching of their eggs would have appeared a mere response to the distressful dangers that threatened the young tadpole. Yet that prepared the conquest of the dry land for the triumphant multitude of the Mesozoic reptiles. It opened a new direction towards a free and vigorous land-life along which all the reptilian animals moved.

And this viviparous, young-tending training that the ancestral mammalia underwent, during that age of inferiority and hardship for them, set going in the world a new continuity of perception, of which even man to-day only begins to appreciate the significance.

§ 3

An Age of Brain Growth.

A number of types of mammal already appear in the Eocene Period. Some are differentiating in one direction, and some in another; some are perfecting themselves as herbivorous quadrupeds, some leap and climb among the trees, some turn back to the water to swim, but all types are unconsciously exploiting and developing the brain which is the instrument of this new power of acquisition and educability. This age of flowers, this age of birds and mammals, the Cenozoic Age, might also be

called the Age of the Growing Brain. In the Eocene rocks are found small early predecessors of the horse (Eohippus), tiny camels, pigs, early tapirs, early hedgehogs, monkeys and lemurs, opossums and carnivores. Now, all these were more or less ancestral to living forms, and all had brains relatively much smaller than their living representatives. There is, for instance, an early rhinoceros-like beast, *Titanotherium*, with a brain not one-tenth the size of that of the existing rhinoceros. The latter is by no means a perfect type of the attentive and submissive student, but even so it is ten times more observant and teachable than its predecessor. This sort of thing is true of all the orders and families that survive until to-day. All the Cenozoic mammals were doing this one thing in common under the urgency of a common necessity; they were all growing brain. It was a parallel advance. In the same order or family to-day, the brain is usually from six to ten times what it was in the Eocene ancestor.

The Eocene Period displayed a whole series of herbivorous brutes of which no representative survives to-day. Such were the *Uintatheres* and the *Titanotheres*. They were ousted by more specialized graminivorous forms as grass spread over the world. In pursuit of such beasts came great swarms of primitive dogs, some as big as bears, and the first cats, one in particular (*Smilodon*), a small fierce-looking creature with big knife-like canines, the first sabre-toothed tiger, which was to develop into greater things. American deposits in the Miocene display a great variety of camels: giraffe camels with long necks, gazelle camels, llamas, and true camels. North America, throughout most of the Cenozoic Period, appears to have been in open and easy continuation with Asia, and when at last the glaciers of the Great Ice Age, and then the Bering Strait came to separate the two great continental regions, the last camels were left in the Old World and the llamas in the New World.

In the Eocene the first ancestors of the elephants appear in northern Africa as snouted creatures; the distinctive elephant's trunk dawned on the world in the Miocene and grew longer with the ages.

§ 4

The World Grows Hard Again.

Through millions of animal generations the spinning world circled about the sun; slowly its orbit, which may have been

nearly circular during the equable days of the early Eocene, was drawn by the attraction of the circling outer planets into a more elliptical form. Its axis of rotation, which heeled over to the plane of its orbit, as the mast of a yacht under sail heels over towards the water, heeled over by imperceptible degrees a little more and a little more. And each year its summer point shifted a little farther from perihelion round its path.

These were small changes to happen to a one-inch ball, circling at a distance of 322 yards from a flaming sun nine feet across, in the course of a few million years. They were changes an immortal astronomer in Neptune, watching the earth from age to age, would have found almost imperceptible. But from the point of view of the abounding mammalian life of the Miocene they mattered profoundly. Age by age the winters grew, on the whole, colder and harder and longer relatively to the summers; age by age the summers grew briefer. On an average the winter snow lay a little later in the spring in each century, and the glaciers in the northern mountains gained an inch this year, receded half an inch next, came on again a few inches. . . .

The Record of the Rocks tells of the increasing chill. The Pliocene was a temperate time, and many of the warmth-loving plants and animals had gone from temperate latitudes. Then, rather less deliberately, some feet or some inches every year, the ice came on into the temperate regions of the earth.

An Arctic fauna—musk-ox, woolly mammoth, woolly rhinoceros, lemming—ushers in the Pleistocene. Over North America and Europe and Asia alike, the ice advanced. For thousands of years it advanced, and then for thousands of years it receded, to advance again. Europe down to the Baltic shores, Britain down to the Thames, North America down to New England, and more centrally as far south as Ohio, lay for ages under glaciers. Enormous volumes of water were withdrawn from the ocean and locked up in those stupendous ice caps so as to cause a world-wide change in the relative levels of land and sea. Vast areas were exposed that are now again sea bottom.

There were four separate Glacial Ages during the million years of the Pleistocene, separated by milder Interglacial Periods as the ice temporarily receded. Meanwhile in Africa, which may well have been the cradle of our genus and species, the Glacial Ages of the north were reflected as periods of extremely heavy and abundant rain.

The world to-day is still coming slowly out of the last of a series of waves of cold. It is not growing warmer steadily. There have been and are fluctuations. Remains of bog-oaks, for example, which grew two or three thousand years ago, are found in Scotland at latitudes in which not even a stunted oak will grow at the present time. This uncertain change towards warmth may go on, or it may not. We do not know.

It is amidst the crescendo and diminuendo of frost and snow in the Pleistocene that we first recognize forms that are like the forms of men. The Age of Mammals culminated in ice and hardship and man.

CHAPTER 6

APES AND SUB-MEN

§ 1

THE origin of man and his relations to other animals has been the subject of great controversies during the last hundred years. The prevailing opinion among men of science is that man, like all other mammals, is descended from ancestors of a lowlier kind, that he and the large apes, the chimpanzee, the orang-outang and the gorilla, had once a common ancestor, and that this ancestor was evolved from yet lower forms, from some earlier type of mammal which was itself descended from a theromorph reptile, and this again from a series of amphibians, and these again from primitive fish. This genealogy is based on the comparison of man's anatomy with that of other vertebrated animals, and it is confirmed by the curious phases through which his body passes before birth. For he begins as if he were to be a fish, with gill-slits and a fish-like heart and kidney, he passes through phases that recall the amphibian and reptile, and then he recapitulates lower mammalian structures. He has for a time a tail. He does not begin human, even in his individual development; he struggles through to humanity. In a score of small things of no advantage to him, in the hair and the direction of the hair upon his limbs, for example, he recalls the ape.

Through millions and millions of lives, man has been shaped to such powers and hopes as he has to-day. He has come from a stir and movement in the waters to this, and he faces now, with a growing consciousness and will, his incalculable racial destinies. The writer follows this view of mans' origins. It

seems to him to be a quite firmly established one. But it is well to bear in mind that the animal ancestry of man is still passionately denied by many able and even learned people. The government of the state of Tennessee, for example, was so convinced to the contrary in the 1920s that it prohibited the teaching of this opinion in any of its schools and colleges. The family scandal is not, apparently, to be mentioned. And the authority of Mr. William Jennings Bryan (who followed his great prototype Jefferson in this matter) was weighed in the scale against the biological world in the trial at Dayton that ensued.

It is sometimes alleged that various religious bodies, and particularly the Roman Catholic Church, are opposed to this view of man's descent from animal ancestors, but this does not seem to be the case. The Roman Catholic Church is no more committed to the view that man was specially created than it is to the doctrine that the world is flat or that it is the centre about which the sun revolves. People once imagined that such were the doctrines of the Church, but all that has since been cleared up quite satisfactorily. Many individual believers dissent from the scientific opinion, because they feel it is more seemly to suppose that man has fallen rather than risen, but their objection does not commit their Church as a whole. The task of the historian is to deal not with what is seemly but with what is true. No considerable Christian body, indeed, now insists upon the exact and literal acceptance of the Bible narrative; to that the freedoms of great poetry are very properly conceded; and so long as the biologist does not insist upon an animal origin for the soul of man there is really no dispute between science and religion in this matter. It is not fair, however, to proceed to an account of man's descent without this preliminary intimation. The writer tells what he believes to be the truth, and it is not for him to state the arguments of opponents which do not appear to him to be valid and to which he could not do justice.

In the case of many of the great mammals it is possible to trace the descent of the existing species almost step by step from an Eocene ancestor. This is so with the elephants, for example, the camels and horses. The series in these instances are very complete. There are multitudes of specimens and close gradations. But it has to be admitted that the fossil remains of human ancestors are rare and imperfect and that broad gaps still remain to be filled in. In the days when the great English naturalist, Charles Darwin, first drew the attention of the world to this question with his *Descent of Man*, the

known prehistoric remains of men were rare and unhelpful. Between the man and the great apes a great gulf seemed to be fixed, and the "missing link" became a by-word in popular discussion. It is only quite recently that vestiges have been found of creatures which seem to bridge that interval. But in the last twenty or thirty years the skulls and teeth and limb-bones have come to light in ever-increasing numbers.

It is frequently alleged that Darwin taught that man is descended from some man-like ape such as the chimpanzee, the orang-outang, or the gorilla, but that of course is as reasonable as saying that I am "descended" from some Hottentot or Esquimaux as young or younger than myself. Others, alive to this objection, say that man is descended from the common ancestor of the chimpanzee, the orang-outang, and the gorilla. Some "anthropologists" have even indulged in a speculation whether mankind may not have a double or treble origin; the negro being descended from a gorilla-like ancestor, the Chinese from an early orang-outang, and the "White" race from a chimpanzee-like ancestor, and so on. The chimpanzee by this brilliant theory is the European's lowly brother, with a better claim to dine and intermarry with the best "Nordic" familes than the more distant negro or Chinaman. These are preposterous ideas, to be mentioned only to be dismissed. It was formerly assumed that the human ancestor was "probably arboreal," but the current idea among those who are qualified to form an opinion seems to be that he was a "ground ape," and that the existing apes have developed in the arboreal direction from a less arboreal origin.

If one puts the skeleton of a man and the skeleton of a gorilla side by side, their general resemblance is so great that it is easy to jump to the conclusion that the former is derived from such a type as the latter by a process of brain growth and general refinement. But if one examines closely into one or two differences the gap widens. Particular stress has recently been laid upon the tread of the foot. Man walks on his toes and his heel; his great toe is his chief lever in walking, as the reader may see for himself if he examines his own footprints on the bathroom floor and notes where the pressure falls as the footprints become fainter. His great toe is the king of his toes.

Among all the apes and monkeys, the only group that have their great toes developed on anything like the same fashion as man are some of the lemurs. The baboon walks on a flat foot and all his toes, using his middle toe as his chief throw off, much as the bear does. And the three great apes all walk on the outer

side of the foot in a very different manner from the walking of man.

The great apes are forest dwellers; their walking is incidental; they have not the nimbleness of monkeys among trees but they are frequently and habitually off the ground. The gorilla is the heaviest and most terrestrial. When they are on the ground they often use their fore-limbs, running on their knuckles in a very unhuman fashion. Their arms are relatively much longer than man's. They have very distinctive methods of climbing; they swing by the arms much more than the monkeys do, and do not, like the latter, take off with a spring from the feet. They have no tails to help them. They have a specially developed climbing style of their own. But man walks so well and runs so swiftly as to suggest a very long ancestry upon the ground. Also, he does not climb well now; he climbs with caution and hesitation.

Conceivably, the precursor of the men and sub-men we shall presently describe was, at the opening of the Cenozoic Period, a running ape living chiefly on the ground, hiding among rocks rather than trees as the Gibraltar monkeys do. It could climb trees fairly well and hold things between its great toe and its second toe (as the Japanese can do this day), but it was already coming down to the ground again from a still remoter, a Mesozoic arboreal ancestry.

Moreover, it is to be noted that man does not swim naturally; he has to learn to swim, and that seems to point to a long-standing separation from rivers and lakes and the sea. It is quite understandable that such a creature would very rarely die in water in such circumstances as to leave bones to become fossilized.

It must always be borne in mind that among its many other imperfections that Geological Record necessarily contains abundant evidence only of water or marsh creatures or of creatures easily and frequently drowned. The same reasons that make any traces of the ancestors of the mammals rare and relatively unprocurable in the Mesozoic rocks probably make the signs of possible human ancestors rare and relatively unprocurable in the Cenozoic rocks. Such knowledge as we have of the earliest men, for example, is almost entirely obtained from a few caves into which they went and in which they have left their marks. Until the hard Pleistocene times they lived and died in the open or in the forest, and their bodies were consumed or decayed altogether.

Moreover, the ancestors of man, like the great apes of to-day, were probably never a very abundant race. They were

not like wild horses and deer, for example, which can go in great herds and have been represented by hundreds and thousands if not millions of individuals in every generation. Plenty of these herbivora would always be getting drowned or pulled into the water by crocodiles or killed in the mud near a drinking-place. They fossilize easily, therefore. The great apes, on the contrary, go alone or in pairs with a young one or so; they range over wide areas in search of food, and drive away other competitors of their own species. They are solitary creatures needing each one a territory of its own. They need very special food. It is doubtful whether there are more than a few thousand and there may be only a few hundred gorillas in the world. Whole generations of them may pass away without a single one being fossilized. There is a mass of reasons for supposing that man's ancestor was a solitary ape of a similar type. He ranged alone or in small families over wide areas. Dozens of kindred species living under such conditions may have passed away completely and left scarcely a trace, and the chances that palæontologists will come upon that trace must be poor indeed.

It is well to bear in mind, also, that the Record of the Rocks has still be be thoroughly examined. It has been studied only for a few generations, and by only a few men in each generation. Until recently, only western Europe had been explored in this connexion. There may be, there probably are, thousands of deposits still untouched containing fragments and vestiges of man and his progenitors. In Asia, in India or the East Indies, or in Africa, the most illuminating clues must be hidden. In America it seems less probable that anything sub-human will be found. But what we know to-day of early man may be the merest scrap of what will presently be known.

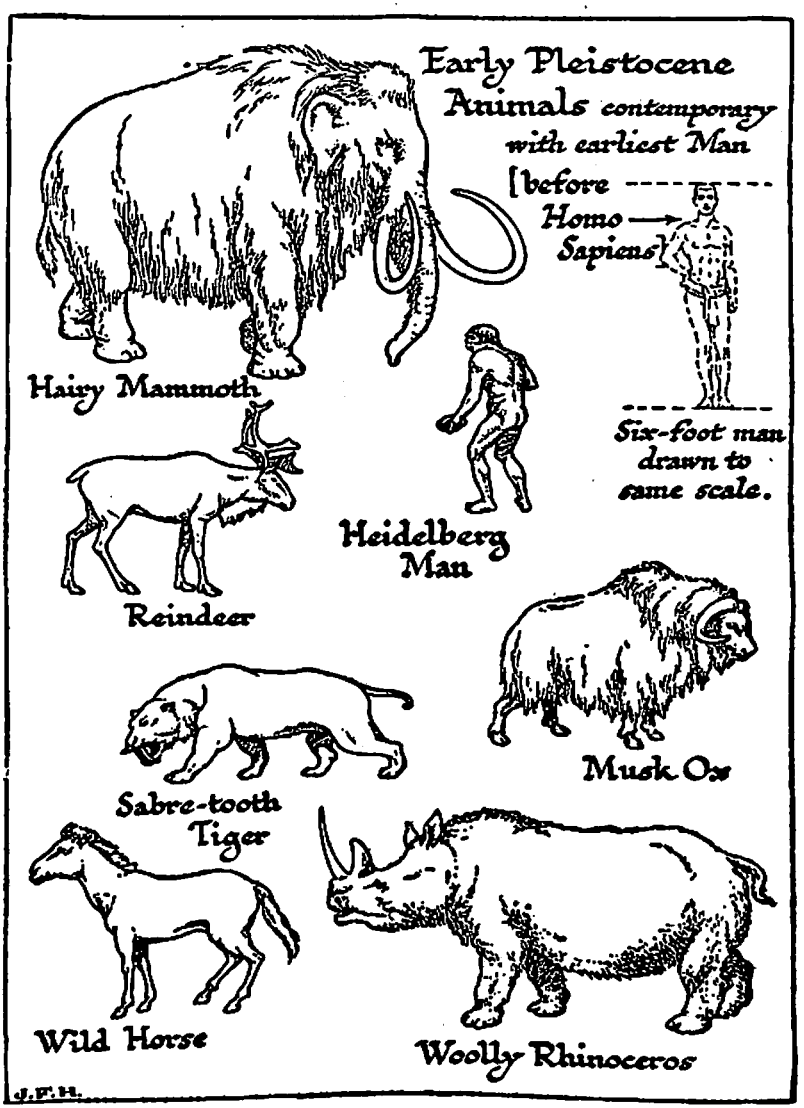
The apes and monkeys appear to have been differentiated already at the beginning of the Cenozoic Age, and there are a number of Miocene and Pliocene apes whose relations to one another and to their sub-human associates, to be presently described, have still to be made out. Africa is particularly rich in their remains, some of them near to the ancestral stock from which two lines diverged—the line that led to modern apes, and the line that led to man.

§ 2

The First Implements.

Probably all of these animals, these near-men, used tools. Charles Darwin represents baboons as opening nuts by breaking them with stones, using stakes to prise up rocks in the hunt for

insects, and striking blows with sticks and stones. The chimpanzee makes itself a sort of tree hut by intertwining branches. Possibly the implement-using disposition was already present in



the Mesozoic ancestors from which we appear to be descended. But the use of tools by monkeys and apes is an improvisation, a picking-up of whatever lies to hand to solve an immediate problem. The early men and sub-men went further than this.

They deliberately shaped their implements for purposes they could foresee, and kept them by for future use.

Among the earliest supposed evidences of some creature more man-like than any living ape on earth, are a number of flints and stones very roughly chipped and shaped so that they can be held in the hand. In many of these, the work is so rough that it may not even have been deliberate. Stones can be chipped and flaked by such natural agencies as frost, or friction between stone and stone when land subsides, or in some places the great differences in temperature between day and night. Perhaps the first stone tools were shaped by such forces, then picked up and kept by their users. The crude "Eoliths" from the Pliocene of Kent and East Anglia, which were described as man-made instruments, may well have been so produced.

The earliest artificially formed tools about which there can be no question are the roughly chipped pebbles and lumps of rock of the so-called Oldowan culture, named after the gorge in Tanganyika where they were first discovered. They have a characteristic pattern, with a jagged cutting edge formed by chipping away one side of the pebble or lump. Similar tools have since been found in sites ranging from Algeria to South Africa, so the culture was spread at least across the African continent. They were of early or middle Pleistocene age. They generally occur without associated human or other remains, and until the last few years it was impossible to describe the quasi-human beings of half-a-million years ago who made them. The tool-makers did not as a rule die or leave the remains of their dead at the living place, and that is where the tools are found. But we can trace the gradual improvement in their skill as the ages went by, and see, in deposits which lie over each other layer by layer, how a roughly chipped pebble led on to a crude handaxe. The latter was probably a general purpose tool, used mainly for cutting, skinning and scraping.

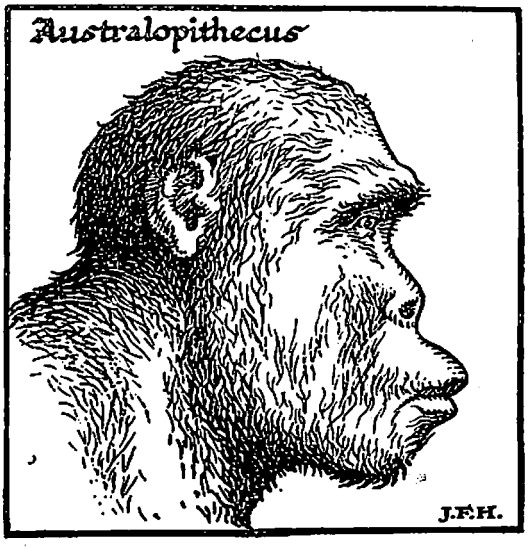
The appearance of manufactured implements marks the beginning of the Palæolithic (Old Stone) Age.

§ 3

Fossil Sub-men.

About contemporary with the earliest known implements are the earliest known bones of sub-men. Nowadays we have rich material of two different grades of sub-human creatures—the African *Australopithecus* (Southern Ape) and the Asian *Pithecanthropus* (Ape-Man). The second appeared rather later than the first and was rather more human; indeed, many

authorities describe it as a man, though nobody classifies it in the same genus with ourselves. The two form a graded series with our own genus *Homo*, and it seems quite likely that *Australopithecus* was an ancestor of *Pithecanthropus*, and *Pithecanthropus* an ancestor of modern man.



The first specimen of *Australopithecus* to be discovered was a single juvenile skull, found in 1925 at Taung in Bechuanaland. It is ape-like in general appearance but curiously man-like in certain details, especially of the teeth. About ten years later a magnificent series of skulls, teeth and other bones began to come from various sites in the Transvaal, where the remains of eighty or more individuals have so far been found, not counting odd teeth and other little fragments. As these paragraphs are written, important new discoveries are announced from Tanganyika.

The remains belonged to creatures of several distinct, but closely related, types. Some authorities believe that the differences are great enough to place the types in separate genera, and use the names *Paranthropus*, *Plesianthropus*, *Telanthropus* and *Zinjanthropus* in addition to *Australopithecus* to distinguish these genera. Others prefer to group them all under the one generic name, and here we take the second and simpler course.

Australopithecus dates back to the early Pleistocene, half a million years or more ago. In general appearance it was neither ape nor man—a creature about four feet high, with an ape-like head and man-like legs. Its brain-case was the size of a gorilla's; its skull was thick, its forehead low and flat, its brows heavy and beetling, its jaw enormous and chinless. It had exceedingly large molar and premolar teeth. But even in the skull, with its ape-like proportions, there are many details that suggest man more than any known ape. The shape of the pelvis and femur and the position of the joint between skull and neck show clearly that *Australopithecus* walked on two legs, nearly as upright as a man and much more so than any known ape.

Standing upright, *Australopithecus* was free to use its hands, and it used them to manufacture the stone tools of the Oldowan culture. To many authorities it appeared at first incredible that a sub-man with a brain no larger than that of an ape could manufacture tools, crude indeed but made to a fairly standard and recognizable pattern; but the newest evidence leaves little room for doubt. At Sterkfontein, in the Transvaal, stone tools and teeth of *Australopithecus* have been found together. In 1959, at Oldovai gorge, Tanganyika, Dr. and Mrs. Leakey found a complete skull and other bones of "*Zinjanthropus*" on its original living site, with stone tools, the waste flakes resulting when the tools were made, and the splintered bones of small animals of many kinds on which the sub-man fed.

So it seems that the very specialized human leg appeared before the human brain—and indeed, the leg may have made the brain possible. These ancestors of ours must have begun as apes with modified hip girdles and legs that allowed them to go upright. They took to the open country, living as scavengers and hunters. With their free hands they picked up sharp flints for use as tools, then began to shape the tools themselves. From then on, as Dr. Oakley has pointed out, the brain might expand very rapidly; as cultures became more elaborate, there would be intense selection in favour of adaptiveness and intelligence.

The next link in the chain, *Pithecanthropus*, was known for many years from a few fragments only—the roof of a skull, some teeth and a thighbone, all found at Trinil in Java in 1891. Many attempts were made to find more, but only in the few years before the Second World War were they successful; then the remains of some half-dozen individuals were collected in central and eastern Java. As far as we can tell, their time was that of

the Second Ice Age in Europe and the interglacial period before it—about 400,000 to 500,000 years ago.

The Javanese ape-man stood rather less than five feet high. It had a thick, flat skull with prominent bony eye-brow ridges and a massive, chinless jaw, but its proportions were not quite as ape-like as those of *Australopithecus*. Its brain was larger than that of *Australopithecus*, and on the average about two-thirds the size of ours. Its limb bones and hip girdle were indistinguishable in shape from those of modern man. Although *Pithecanthropus* was sub-human in face and presumably in mind, it could stand and run as well as we do.

A variant came from China. In the late twenties and the thirties, a great number of teeth and skulls and several limb bones were unearthed at Choukoutien, near Pekin. They were first described as a separate genus, *Sinanthropus*, but are nowadays included in *Pithecanthropus* though not in the original species. The new form was a little more advanced in the direction of manhood than his Javanese relative, especially in the size of the brain, and he probably lived a little later. But his bones are now known only from published descriptions and plaster casts, for the whole of this precious collection vanished during the Second World War. Probably it was sunk while being sent by sea to a place of safety.

Nothing is known about the way of life of the Java ape-man. The Chinese one certainly made tools of flint and bone and knew the use of fire, for tools and hearths and charred bones of the deer which it hunted, cooked and ate are found in the same deposits with its own remains.

Vestiges are known of various other sub-men whose place in the story is still doubtful. For example, there is a jawbone found in a sand pit near Heidelberg at a depth of eighty feet