EDITED BY E. HALDEMAN-JULIUS

THE KEY TO EVOLUTION

Maynard Shipley

In Four Double Volumes

VOLUME 5

From Amphibian to Man

VOLUME 6

Man, Cousin to the Apes

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KEY TO EVOLUTION NO. 5
Edited by E. Haldeman-Julius

From Amphibian to Man

The Origin of Higher Land Animals

Maynard Shipley

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"To add new facts to any science involves the expenditure of much time and thought, and usually also money; yet many are in the field and are striving ceaselessly in this direction. But is it a less worthy object to strive for the alignment of the facts which we already have?"

—W. Denham Verschoyle,
"Electricity: What Is It?"

"To experience we refer, as the only ground of all physical inquiry. But before experience itself can be used with advantage, there is one preliminary step to make, which depends wholly on ourselves: it is the absolute dismissal and clearing of the mind of all prejudice from whatever source arising, and the determination to stand or fall by the result of a direct appeal to facts in the first instance, and of strict logical deduction from them afterwards."

—Sir John Herschell,
"Discourse on the Study of Natural Philosophy."

FROM AMPHIBIAN TO MAN

INTRODUCTION

IN the present volume, as in those preceding, the attempt has been made to emphasize points and to present data which have been more or less neglected in the more "popular" works on evolution. No doubt this plan involves some sacrifice of the entertainment element, and, in some cases, may lead to a certain tediousness. But it is hoped that the solid information thus to be gained will be well worth the close attention that must often be given when coming into contact with unfamiliar terms and phrases. However, no effort has been spared to make every word understandable, by the introduction of definitions or explanations wherever feasible, within brackets, where the technical language employed is within quotation marks.

It was intended, from the outset, to bring the general reader into direct contact with the greatest living authorities on the various branches of science bearing on evolution. In many cases, it will be observed, the expert's own words have been cited in preference to a paraphrased statement by myself. By this method the reader becomes acquainted not only with the views or conclusions of our more eminent workers in the several fields of natural science, but also with the most authoritative recent works, and even some technical papers, dealing with the facts and theories of evolution.

And could anyone hope to learn anything more important than the facts which fully sustain the great evolutionary concept? It has frequently been stated that "evolution has revolutionized human thought." Every year brings forward indubitable confirmation of this statement. To say "evolution" nowadays is to say "science"; and to say "science" is to bring to mind, to those who have had the good fortune to read Elliot Rowland Downing's "A Source Book of Biological Nature-Study" (1919), his appreciation of the great contributions of science to the evolving life of mankind. He names, as values we should highly appreciate,

> its emphasis on the scientific mode of thinking or the problem-seeking, problem-solving attitude of mind; a mass of scientific knowledge that serves as the basis for desirable skills; and an interpretation of Nature productive of an inspiring appreciation, both intellectual and esthetic, of her phenomena.

The work of the geologist, paleontologist, or zoologist may appear, from a certain point of view, to be somewhat unrelated to the thinking processes even of rather highly educated persons. I think that Prof. J. Arthur Thomson gave a good reply to this attitude of mind some years ago (1911), in his interesting work, "The Study of Animal Life":

The zoologist has deliberately given himself up to analysis, and if the world is to become translucent to us, we much include within our knowledge what he can tell us about the structure and activities of animals, alike as unities and as complex combinations of organs, tissues and cells.

The late Prof. John M. Coulter (1851-1929), in his comparatively recent work, "Evolution," emphatically declared that

every subject that is worthy of study or that is worthily studied is considered now from the standpoint of evolution. Before the idea of evolution began to control thinking men, a fact was considered by itself, without reference to any other fact. Now facts are accumulated in order that they may be put together and made to explain one another. We observe a fact and ask what other fact causes it; and so facts are linked together in a continuous chain, each fact dependent on facts that have gone before, and responsible for facts that have come after. . . . It is evident that the idea of evolution does not belong to any particular subject, but that it suggests a method of studying any subject. If the idea of evolution has had such an influence upon thought and work, it is clear that thoughtful people should understand it, at least in a general way. . . . One of the most important and difficult things for anyone to learn is to express no opinion until it is based on knowledge. To keep an open mind is what every student must learn to do.

If the reader of the facts which I have assembled in the pages following will keep before his mind's eye, so to speak, the foregoing statements, it is very likely that he will derive at least some profit from the perusal of this volume.

After having stated that "the idea of evolution is the most potent thought-economizing formula which the world has yet known," Prof. J. Arthur Thompson, the celebrated British naturalist, remarks:

In accepting the evolution idea we lose no small part of its virtue if we do not visualize it, if we do not, in some measure, image the relative simplicity of life's beginnings and the long pageant that has passed in gorgeous procession over the earth for millions of years; if we do not understand that evolution is going on still and that it includes us and our doings in its sweep.

Thomson's words are profoundly true. He who is not able at will actually to picture in his mind's eye the long course of evolution will be unable to apply the principles of Darwinism to psychological, religious, ethical, and social problems. If it is asked, "How can a knowledge of evolution and Darwinism help me in the struggle for existence?" I can but agree with Thomson in saying:

Darwin set a-going a kind of inquiry into individual development and racial evolution, into variation and heredity which promises to give us a firmer control of life. We are only beginning to realize that the truth that is in Darwinism shares with all truth the power of making us free.

Perhaps no one has put the importance of the study of evolution more clearly than has the eminent English scientist, Sir Charles Scott Sherrington ("Creation by Evolution," p. xxi):

The creation of man perceived as a gradual and still operative evolutionary process, which, besides bringing him into existence is still molding him and will not leave him where he is and as he is, bears broadly and profoundly on the interpreta-

tion of all human activities. This perception affords him new guidance in tracing to their origins his instincts, his emotions, his interests, and his reasoning power. In the light of this perception civilization and the history of civilization acquire fresh meanings; human society—its customs, its duties, and its growth—stands visible from a new angle and in truer perspective. There is incumbent, therefore, on every thinking man and woman, faced with the responsibilities of citizenship, an obligation to inform himself or herself, in at least some measure, of the nature and bearings of the great fact of evolution. Its principle is a part of established knowledge, acquaintance with which, by reason of the enlightenment it sheds on life, each one of us, for our own sake and for the sake of others, should possess.

Man's big job consists of two paramount activities: adjustment of himself, as a mammal, to his environment; and adjustment (modification) of the environment to himself. Without the development of these two capacities, man, like an amphibian or a gorilla, is at the mercy of Nature. A serious study of evolution (which includes its methods or processes) leads to mastership of Nature, by learning how to control "natural laws" (really there are no such "laws"), or to adapt oneself to natural processes or to control these processes in one's own interests. Any and every form of superstition or supernaturalism either makes this advance impossible or retards the progress of mankind in self-protective operations or adjustments.

Prof. Sir William D. Tait, of McGill University, Canada, has contributed an article to *The Scientific Monthly* (August, 1929, pp. 132-136) which would well repay reading by any thoughtful person. His point is that even now we have sufficient knowledge of the right kind at our command to make nature a servant, instead of a master, of mankind.

> Man's advance in civilization is thus to be measured in terms of nicety of adjustment to his environment, or to put it otherwise, his efficiency in meeting his environment is the measure of his civilization, and the records of this advance are to be found in the annals of science. This increased efficiency can only come about by man's knowing more about the world in which he lives, no matter whether it be the so-called outer world of nature, his fellow-man, or even himself. . . . Simple as the statement may appear that science [which, in our day, means a knowledge of evolution] enables man efficiently and competently to meet his environment and thus make progress as a civilized human being, yet it has some profound and far-reaching consequences. It means, first of all, that we are, as yet, only at the beginnings of science, and it means, too, that in the struggle for existence, which struggle is unending, the individual or nation or race which knows most about the conditions to be met and the way to meet them, in other words, the one with the best scientific equipment, is the one which will survive. That inexorable law of selection still holds, but in a very intricate, refined, and subtle way. Ignorance spells non-adaptability, failure, defeat, and submergence. . . . [It is only by] rigid scientific procedure in all the affairs of life that a people can become and remain efficient and cultured.

Imbedded in ancient rocks are the fossil remains of thousands of extinct animals, revealing the slow evolution of life from the lowest one-celled plant-animal, on up to the savage, and, in many cases, ape-like prehistoric ancestors of man. It was the great Sir John F. W. Herschel who said: "Geology in the magnitude and sublimity of the objects which it treats ranks next to astronomy in the scale of science." And John Ruskin declared that "geology does better in re-clothing dry bones and revealing lost creations than in tracing veins of lead or beds of iron."

Scientists have unrolled monster leaves (strata) in the Great Book of Nature (the earth) and have translated for our edification and entertainment the strange hieroglyphics in which Mother Earth has written her autobiography. And a wonderful romance it is, for "The earth hath gathered to her breast again and yet again, the millions that were born of her unnumbered, unremembered tribes."

CHAPTER I

FROM FINS TO LIMBS

IN the preceding volume of this series, we saw how all the available evidences point directly to the fact that all of the land vertebrates had their origin in one or the other of two groups of Devonian fishes. The members of both groups possessed lungs; and one group at least (the fringe-finned Ganoids) had the beginnings, or foundation structure of limbs—a developing terrestrial locomotor apparatus. Some of the evidence for this conclusion of scientists was not given in the previous volume because of its highly technical nature; that is to say, the most elementary statement of the (additional) facts in support of the fin-origin of man's limbs would require so many anatomical definitions in brackets, that it would make the reading of our story unduly difficult to the average person. It was therefore deemed advisable to let the matter rest as presented.

However, it may be permissible to add a few more fundamental facts at this point in our narrative. Of special interest to the serious student of evolution is the problem of how the shoulder-blades of an ancient lobe-finned fish could have developed into the shoulder-girdle, or scapula, as the anatomist calls this structure, of all land-living vertebrates, including man. Full details are presented by Dr. William King Gregory, in his great monograph, "The Upright Posture of Man," pp. 349-350, where the direct paleontological evidence is set forth, thanks partly to the splendid researches of Prof. D. M. S. Watson ("Evolution of Amphibia," *Philosophical Transactions* of the Royal Society [B] Vol. 209, 1919). In his study of the Carboniferous strata of Great Britain, this eminent scientist, professor of zoology in the University of London, discovered an "almost ideally intermediate" type of shoulder-girdle in the fossil form named by him *Eogyrinus*, filling the erstwhile gap between the lobe-finned fish and the oldest known amphibian. According to Professor Gregory,

> The subsequent evolution of the shoulder-girdle from the earliest amphibian to man is now well understood and may be reviewed in a few words. The cleithrum, which . . . forms the largest part of the shoulder-girdle of fishes, suffered progressive reduction in the series of mammal-like reptiles until in the early mammals it has either disappeared entirely, or, according to Broom, become reduced to the condition of a vestigial dermal cap on the acromial process of the scapula. The lowest of the existing mammals, the monotremes of Australia, still retain a well-developed interclavicle but in animals above the monotremes this element becomes vestigial or entirely disappears.

Our authority then goes on to explain how the pelvis and hind limbs of land vertebrates originated, and leaves nothing to be desired in tracing, step by step, the successive stages by which fins became limbs.

Naturally enough, the first attempts at land locomotion were very clumsy. Says Gregory:

> In the earliest attempts at locomotion, the wriggling movement of the body brought about by the zigzag muscle segments of the flanks was still the primary source of forward locomotion, the hands and feet serving primarily as temporary braces for the alternating transmission of this wriggling thrust to the ground as the body swayed and bent first to one side, then to the other. Presently the ventral surface was lifted completely off the ground and henceforth the creature relied solely for propulsion upon the lengthening or extension of the limbs. From the very first the limbs acted as jointed compound levers which alternately folded up and extended, on the very same principle which is still found operating in the legs of man. From the first also there was a criss-cross alternation of flexion and extension of the fore and hind limbs, according to which, for example, the right fore limbs would be moving backward while the left hind limb was moving forward, *just as our arms swing alternatively with the movements of our legs in walking* [italics mine].

The early amphibians, whose skeletons are known to us, were still primitive, not only in the Devonian Period, but also in Carboniferous times (Mississippian period) that is to say, about 350,000,000 years ago. We know that they were still fish-like and resembled in many ways the lobe-finned fishes from which, as the evidence previously presented clearly shows, they were gradually evolved. This transition was doubtless a matter of tens of millions of years, and, according to Osborn and other competent paleontologists, took place in Lower Devonian if not in Upper Silurian times. They proved themselves to be a highly plastic and adaptable form of animal, responding readily to secular changes of environment, some eventually evolving into types adapted to extremely arid conditions. By Middle Devonian time the various forms of Amphibia had become distributed over a wide area of the earth's surface, and they continued to flourish until the end of the coal-forming period. In size, they range from about two inches to more than ten feet (Loxomma)—about the size of an adult Florida alligator. The various stages of this progressive evolution are well represented by fossils preserved in the Coal Measures of Scotland, Bohemia, Ohio (at Linton), and Pennsylvania. In all, the coal swamps have brought to light 46 genera and 88 species of Stegacephela—*the most primitive Order of Amphibia*, in which the membrane-bones made a complete covering to the skull.

Here the evolutionist naturally asks, whence these armor-plate protective bones? Many of these bones have been identified with those of ancient fishes, especially of the order *Osteolepidoti*—e. g., Osteolepis, Sauripterus. In other words, the "armor" was a heritage from the fish ancestors. (See Roy Lee Moodie, "The Coal Measures Amphibia of North America," in which 90 species of Amphibia are fully described. *Publications* of the Carnegie Institution of Washington, No. 238).

It could hardly be doubted that the average intelligent reader would naturally assume that there is a greater "gap," from the standpoint of evolution, between sharks and the Amphibians (or Batrachians) than between the (higher) bony fishes and the sharks. This, however, is not the opinion of experts in zoology. There is more difference between

the bony fishes and the Selachians (sharks and rays) than there is between bony fishes and the lowest types of Amphibia. There is not a zoologist in the world today who would disagree with this conclusion.

In the preceding volume it was shown that for tens of millions of years there was not an animal on earth (or in the sea) that possessed *jaws*. Now, the sharks *have* jaws—and from them came the jaws and teeth of all higher animals. Whence the *first* pair of jaws, inherited by Amphibia, and eventually by Man?

Regan (1906) pointed out that the Selachians were cranial vertebrates "with gills supported by visceral arches, *one pair of which is modified into jaws*" (C. T. Regan, Papers on Classification of Fishes, *Ann. Mag. Nat. Hist.*, 1909-13; "Classification of Selachians," *Proc. Zool. Soc.*, Vol. 2, October 10, 1906). Reichert was first to suggest that the bony chain of the middle ear of man has been derived, by gradual modification and adaptation, from a portion of a modified gill-arch—i. e., the mandibular cartilage (lower jaw) of the fish.

A clear picture of the still fish-like earliest land animals, and the environmental changes which led to their further evolution, is given by Prof. Osborn in his splendid work, "Origin and Evolution of Life," (pp. 177-178):

> **The earliest of terrestrio-aquatic types have not only a dual breathing system** of gills and lungs, but a dual motor equipment of limbs and of a propelling median fin in the tail region. . . . The primordial Amphibia in their form were chiefly of the small-headed, long-bodied, small-limbed [scarcely raising them from the ground], tail-propelled type of the modern salamander and newt. . . . In Upper Carboniferous and early Permian time *the terrestrial amphibians began to be favored by the land elevation* and recession of the sea which distinguished the close of the Carboniferous and early Permian time. . . . One ancestral feature of the amphibians is a layer of superficial body scales in some types, which appear to be derived from those of their lobe-finned fish ancestors; with the loss of these scales most of the Amphibia lost the power for forming a bony dermal armature.

Many features in the evolution of all preceding classes of animals —from Protozoa to Amphibia—are still recapitulated in a few days in the development, and later metamorphosis, from the tadpole to the frog. (A section will be devoted to the phenomena of embryology in the seventh volume of this series.)

The Stegocephalia (Greek for covered, mailed, or solid-headed), Palaeozoic Amphibia, *along with very primitive forms of the Reptilia*, chiefly belong to late Carboniferous (Pennsylvanian) and early Permian time. In the struggle for existence on the land, it was a great advantage to these creatures that the chest also was protected with thick dermal bones, or "armor," consisting of three large "plates," *which represented a part of the bones of the pectoral arch of the fishes* and were the source of the shoulder-girdle (shoulder-blade) of higher vertebrates. In some forms (*Branchiosauria*), both dermal plates and scales were absent, and they were therefore, essentially "naked," as are nearly all living Amphibia (scales being present now only in the Caecilians [*Apoda*], limbless Amphibia, sometimes, but erroneously, called "blind worms," a small

group of about fifty species. Although the skin of these burrowing creatures is smooth and shiny (in ring-like folds), small, deep-set dermal scales occur, an inheritance from the ancient stegocephalian ancestors. Here, too, we meet with a cranium which is very solid and compact in appearance, more like that of primitive reptiles than like modern amphibia. The eyes are rudimentary and practically functionless, as in most burrowing and cave animals. In all the Amphibia—as, indeed, in Man himself!—the fish-like muscular connections of the throat with the collar-bone, and of the collar-bone with the back of the skull, still persist.

The armored amphibia (stegocephalians) first appeared—not counting a foot impression (*Thinopus*) from the Upper Devonian, which was probably a very primitive stegocephalian amphibian—in North America in Devonian time and continued to flourish until the Permian, dying out during the (succeeding) Triassic (first period of the Mesozoic Era, or Age of Reptiles).

The Pennsylvanian—whose strata were laid down about 85,000,000 years after Devonian times—was a period of mountain making, all of North America being dry land—i. e., having no inland (epeiric) seas, which were formerly more extensive than the land area. This condition of land uplift continued into the Permian, which followed, and lasted for about 25,000,000 years, culminating in the making of the Appalachians, the Onachitas, and the ancestral Rocky Mountains. During the last third of the Lower Permian time a *glacial period*, quite as cold as that of the Pleistocene, set in, along with widespread arid conditions. The less adaptable (or more highly specialized) stocks finally perished, both plant and animal forms.

It appears that the first amphibian *bones* (as distinguished from mere foot impressions) are from the Edinburgh Coal Measures of Scotland, which have been referred to the Lower Carboniferous; and they are therefore of equivalent age to footprints found in Nova Scotia.

Prof. Roy L. Moodie, of the University of Illinois Medical School, called attention in 1920 to fossils found in Mason Creek, in northern Illinois, which he considered as among the most primitive of land vertebrates. In a contribution to *The Scientific Monthly*, he said:

> There is a small stream in northern Illinois which, since the last great ice sheet retreated, has cut its unhurried way through some forty feet of glacial alluvium and has thus exposed in its present bed the shales and rocks of the Old Coal Period which was the witness of Nature's most important moment. The old Indian name "Mazon" still clings to the stream and it has become famous the world over for the wonder and importance of the relics of ancient animal and plant life found along its banks. Locally the creek is held in contempt, by the grown-ups as a breeding place for mosquitoes, and by the small boys because it is nowhere deep enough for a good swimming hole; fishing is almost unknown. The winding ripples, however, offer pleasant prospects to the casual visitor and its banks hold untold treasures for the student of ancient life.
>
> The water has worn its placid ways for centuries through several feet of grayish red shales, washing out an occasional rounded nodule, which, becoming exposed to the action of the frost, cracks, and thus discloses its buried treasure of Palaeozoic insect, centipede, spider, fish, leaf, or, very, very rarely, the remains of the first animal with legs, which resembles so very closely our present mud-puppies. These small creatures are the oldest known land vertebrates and represent that most interesting and romantic phase when the animals which later resulted in the evolu-

tion of man were beginning to come out of the water and live a portion of their existence on land.

These little fellows, whose fossils we find on the banks of Mazon Creek, were timid adventurers and stayed close to the shore of the old brackish bayou, the relics of which have come down to delight modern students in their attempt to unravel the story of the old world. None of them exceeded eight or at most ten inches in length, and they were often surpassed in size by even the centipedes which crawled through the swamps with them. But in potentialities of development these small knights of the Palaeozoic surpassed anything the world had ever seen or will ever see again. They marked an important stage in this great progression of vertebrate life which has resulted in the development of the animate world as it is today.

CHAPTER II

EVOLUTION AND CHANGING ENVIRONMENT

WE have seen, in the preceding volume, that at a certain stage in the development of our planet, the oceanic areas of the earth became less extensive; that arid conditions prevailed over large sections of the various continents, as evidenced by the character of the deposits at present known to geologists. Many a swamp, pond, lake, or stream slowly dried out. An invasion of the land surfaces by amphibian-like fishes naturally followed. The evolution of land vertebrates naturally required important modifications of the respiratory apparatus, and transformation of the fins of the Fish into feet capable of treading dry land. In a general way, in outline, we have already seen *how* this evolution came about. *That* it came about is demonstrated both by the fossil record and by the facts of embryology —of which I shall have occasion to speak more at length later.

The organs we call lungs in the Dipnoid Fish, and in some, if not all, of the Ganoids, are in no way different, in their vascular qualities, from the branchial or "lung pouches" of the higher vertebrate groups. Prof. Edmond Perrier ("The Earth Before History," p. 175) says:

> They are themselves exactly equivalent to the lungs of the Batrachians [=*Anura*, i.e., frogs and toads], which are provided in their early stages, and sometimes throughout their whole life, with external branchiae. . . . *The same mechanisms acting on organisms of the same fundamental constitution produce the same effects,* [therefore the known facts force us to assume, logically] that the Batrachians owe their external branchiae [in early stages of individual development] and their lungs to the fact that their ancestors had for a long time lived in waters frequently polluted, i.e., in swamps or muddy rivers, as the Dipnoi [lung-fishes] certainly did [and, often, still do]. The principle just invoked, moreover, is the same that has brought about those resemblances, due to causes other than heredity [which are always distinguishable], which are found among different animals, and which recently have been called *convergence*—a term far less exact than Isidore Geoffroy Saint-Hilaire's expression, *parallelism.*

Professor Perrier then asks, "can it be doubted that the amphibious Batrachians [meaning Amphibians in the wider sense] are descended from Fish, and form the link uniting them with the first definitely terrestrial Vertebrates, the Reptiles?"

Just here let me remark that there is no such thing as a "law of evolution," impelling progressive development to higher forms. There is spontaneous variation under certain environmental conditions leading, wherever possible, to *successful adaptation.* There is no "law of progress," or of progressive evolution, in the Spencerian sense. Radical changes of environment precede radical transformations of structure and function.

Before the Devonian Period (which carries us back at least 450,-

000,000 years ago), and more especially during this stage (Devonian) in the evolution of life on earth, a wide area of dry lands had emerged, and, in due course of time and physical events, had become clothed with an abundant forest flora—though the "grass" of the Holy Scriptures, and the "fruit tree yielding fruit after his kind" were as yet many millions of years—about 150,000,000—off (according to the uranium-lead-helium content of the superimposed strata).

The first Vertebrates to become adapted to terrestrial life were, naturally, the ancestral Amphibia, and "they ruled their various environments certainly from late Devonian until well into Pennsylvanian time" (some 60,000,000 years after the Devonian, which seems to have persisted for about 50,000,000 years, followed by the "Mississippian," of about the same duration). The so-called Pennsylvanian preceded the Permian, which brought to a close—by a widespread period of land elevation, accompanied by a Glacial Period in some areas—the Palaeozoic Era, or "the Age of Fishes and Amphibians." Then followed the Mesozoic Era, or the Age of Reptiles.

Had the physical environment remained constant for all organisms during the first thousand million years of the earth's history—and a period of geologic history of this enormous duration had almost certainly passed before the *beginning* of the Palaeozoic Era which we know as the Cambrian Period (in which fossils for the first time become abundant)—there would have been little or no progressive evolution by virtue of "resident forces." Hence the history of organic evolution is not a record of the operation of some mystical law of progress, but of adaptation to a changing environment, plus "the struggle for existence."

In the Amphibia, then, we meet, for the first time (after some 200,000,000 years of vertebrate evolution) with animals possessing a three-chambered heart (the fish-heart is two-chambered), and a mobile muscular tongue, along with legs, instead of fins, each leg bearing fingers or toes. Lungs and functional nostrils were nearly always present in the adult, though they breathed by gills when very young, as do all the fishes. Among the salamanders, the lungs may be reduced to vestiges, or completely suppressed.

Although the Amphibia were the dominant type of land fauna in the Devonian period, today they occupy, in comparison with other classes of animals, a very insignificant position (about 900 species, mostly of the frog kind; but the Class includes toads, newts, sirens, mud-puppies, water-dogs, and land salamanders—all cold-blooded animals). No amphibian can live in salt water, which points to fresh-water bodies as the place of their origin. Those marine fishes which migrate to fresh water during the breeding season almost certainly had a similar place of origin.

In the case of nearly all of the Amphibia living today, the eggs are fertilized in the water and develop there very much as do those of the fishes; and, on the contrary, very little as do those of the higher vertebrates. In about two months, on an average, the young amphibians attain a stage equivalent to that of the lung-fishes. After a period of from a few weeks to a few months, during which they undergo a marked metamorphosis, "we see a recapitulation of Palaeozoic history that con-

sumed millenniums of selection of the most fit for their environment" (Prof. Charles Schuchert, "Text Book of Geology," Vol. II, p. 405). From the viewpoint of historical geology, as Professor Schuchert further points out, the *Urodela* or tailed Amphibia (as distinguished from the *Anura*, frogs and toads) are of great significance, for this sub-class of Amphibia must have had its origin in the Palaeozóic Stegocephalia (solid-headed amphibians). The number of toes on each foot varies between five, the usual number, and two. Some forms, like the land salamanders, when mature may live wholly on land and lose all traces of the gills, while others, such as the mud-puppies, remain in the water and preserve the gills throughout life. "The Japanese and Chinese giant mud-puppy," says Schuchert (*Op. cit.*, p. 409), "is the largest of all the Urodela, attaining a length of five feet. One individual lived in captivity for over fifty years."

Very few amphibians live far from water. However, the black salamander of the Alps (*Salamandra atra*) inhabits a territory where pools are scarce, and the young, after a period of living and breathing within the mother, are born as lung-breathers. Some species of tree-frogs (*Hylades*) omit the gilled stage of development. In Porto Rico, also, there are frogs that have eliminated the "pollywog" stage. In a letter to *The Atlantic Monthly*, Anne H. Wall states that K. P. Schmidt, herpetologist of the American Museum of Natural History,

found on El Yunque a frog that laid tiny transparent eggs in which could be seen the already developed babies whom fate had spared the tadpole stage. I well remember how our house fairly crept and crawled with specimens brought in by two greatly interested small sons; and particularly the astonishment of us all when Mr. Schmidt produced his vial of transparent eggs with the midget frogs sitting in state therein.

Not only the head, the skull of which is covered with a compact mosaic of membrane-bones, reminiscent of the lung-fish cranium, but also the brains of the Amphibia recall in many points those of the Dipnoi. The axis of the brain appears straight, as in fishes; in higher Vertebrates this axis is more or less folded. The cerebral hemispheres of the fore-brain are, as might be expected, relatively large, as compared with those of fishes. The circularatory system closely resembles that of the Dipnois —or of the ancient fringe-finned Ganoids. In the frog, the heart closely resembles that of the Australian lung-fish Ceratodus, which already shows the beginning of the subdivision of the auricle into two, with the pulmonary veins running into the left subdivision. In the frog, the division of the atrium is complete, and the blood from the lungs returns direct to the left auricle by the pulmonary veins. There is only one ventricle. All warm-blooded animals have two auricles and two ventricles. The kidneys and reproductive organs of Amphibia show essentially the same arrangements as in the sharks (Elasmobranchs), the kidney being divided into a sexual part connected with the testis and a posterior non-sexual part. As in fishes, there is but one opening for all ejecta, the cloaca. But there is one organ never found in the fishes, the so-called *allantoic bladder*. This is formed from the ventral wall of the cloaca, which is produced outwards into a rather large thin-walled sac,

or bladder, in which the urine accumulates when the cloaca is closed. This organ acquires great importance in the evolution of the higher animals.

All the progressive changes just noted are adaptations to new needs due to new environmental changes. They are not the product of some metaphysical directivity or of a mythical "law".

CHAPTER III

THE ROMANCE OF "GONDWANALAND"

IN a recent illustrated article, entitled "What the World Owes to South Africa" (*The Scientific American*, August, 1929, pp. 119-121), Prof. Robert Broom states that at the end of the Coal Period, about 300 million years ago, the lands of the southern hemisphere became divided from the north by a long east-west sea. At this time a vast continent, extending from South America to Africa, part of India, and Australia, appeared—the present Malay Archipelago therefore being then part of this vast southern continent. Professor Broom is of the opinion that most of the South Atlantic and the Indian Oceans were then land and formed part of this great continent, known to geologists as "Gondwanaland." It is quite impossible to explain either the past or the present geographical distribution of plants and animals without the existence of this continent. Under such circumstances, any possible *theoretical* objections of a geophysical nature must yield to the plain observational evidences. Dr. Broom remarks:

> For a time, much of Gondwanaland was covered by ice; but soon after the end of the Coal Period, temperate and even tropical conditions prevailed, and new types of animals and plants began to make their appearance. In South Africa we are fortunate in having a most wonderful record of the progress of evolution during the five or ten millions of years that followed the Coal Period. We have an uninterrupted succession of shales which by their fossils reveal to us better than in any other part of the world, the evolution of animals for long periods of time. . . . The lower layers show us the life of the earlier times—the upper layers, as deposited, of the later. The lower shales are not very rich in animal life, but are interesting as showing us a peculiar little fresh water, lizard-like animal which also inhabited Brazil.

How did it reach Brazil if there was no "Gondwanaland"? Be it noted that all evidence is against the supposition that animals of the same genus have, at times, arisen independently in different parts of the world. A common origin and migration explain all the known facts. But the general question of the geographical distribution of plants and animals is reserved for the eighth volume of this "Key".

In the later deposits of the Karoo formation, Broom and other geologists have found fossil reptiles that are well on the way to the warm-blooded mammalian stage. Of these Broom says that there can be no doubt that they are the ancestors of the higher forms of today.

> Many of these mammal-like reptiles had teeth arranged like the teeth of a dog, with large eye-teeth, and they had the same number of joints in their fingers and toes that man has today. . . . We have hundreds of different mammal-like reptiles—primitive types in the lower beds, and in the upper layers the remains of animals so like the mammals of today that it is not always possible to be quite sure whether they were cold blooded or warm like true mammals.

Professor Broom states that at the very time when Gondwanaland was blossoming forth with new and higher types of plant and animal life, there was little or no evolution taking place in the northern continent —a period (Permian) during which there existed a broad land connection between Alaska, all of what is now the United States, Iceland, Greenland, Europe, and Siberia.

Following the Permian Period—a system of rocks named after the province of Perm, in eastern Russia—which closed the Palaeozoic Era (Age of Ancient Life), begins the Mesozoic Era (Age of Medieval Life, or Age of Reptiles), the first division of which is called the Triassic (because of its threefold stratigraphic nature). From this time on, the rocks of the whole northern continent reveal new forms of plant and animal life, in an evolutionary series. Whence came these more highly evolved forms of life? Broom says:

> It was merely the result of a portion of the dividing sea's becoming land, and the new types of animals and plants that had been evolving in Gondwanaland overflowing into the northern lands and "civilizing" them. Almost all the wonderful new types of animals and plants that have been discovered in the Triassic rocks of the north are now known to be related to somewhat similar forms that lived many years before in Gondwanaland.

Broom is confident that when the South African beds "have been more fully studied, we will probably have all the steps we could desire in the evolution of these many higher types of life."

While some group or groups of South African Amphibia (a Greek term meaning "leading a double life," or one in two places) were progressing toward the reptilian stage of evolution, a somewhat similar developmental process was going on in North America. In the Upper Devonian shales of Pennsylvania was found the earliest proof so far discovered that the long period of transition of the vertebrates, from the fish type to the amphibian type, had been achieved—the single impression of a three-toed footprint (*Thinopus antiquus*). In sediments of the Mississippian Period, which followed, we find tracks of many kinds of amphibians, those earliest vertebrates to walk on land. Throughout the continental deposits of Pennsylvania, known as the Maunch Chunk, many footprints of amphibians have been discovered, but most of them have not yet been described. As long ago as 1849, Lea found what is described by Schuchert (*Op. cit.*, p. 342), as

> a most interesting slab, a little over five feet long, with six successive foot impressions made by an amphibian (*Palaeosauropus*) with a thirteen-inch stride. This slab is ripple-marked and has rain imprints, indicating a mud flat of land origin, over which the animal walked when the deposit was soft and wet. [Noachic-flood geologists, please note!] Another amphibian track has been found in Giles county, Virginia (*Dromopus*).

Dr. Schuchert, in a splendid chapter (XXX) of the text-book previously cited, gives us a clear picture of conditions during the period now under discussion. To quote a few illuminating passages (pp. 420-422):

> The glacial climate and the subsequent long-continued arid conditions wrought a mighty change in the life both of the lands and oceans. We have seen that for

a long time before the Permian the climate had been mild the world over [though at least two glacial epochs had come and gone before the end of the Cambrian—some 300,000,000 years *previously*], and that "no animal could endure the least cold." Accordingly the Permian was an age of hardship and struggle for all life, and brought death to many of the specialized [i.e., non-plastic, non-adaptable] stocks. With the glacial climate, there came into existence a hardier flora in the southern hemisphere known as the *Gangamopteris flora,* which in later Permian time had in Asia spread to the Arctic Ocean. [The Permian rocks of Australia, India, South Africa, and South America give evidence of widespread glacial ice—some 300,000,000 years *ago!* The rigors of this time, and in this wide region, expelled, or exterminated, many of the members of the early cosmopolitan flora and introduced a number of new types, known collectively as the Glossopteris flora.] This flora provided a different, and probably a better food for the insects and reptiles of the land, and accordingly we see a marked evolution among them. In the seas there was a great dying out of many kinds of brachiopods [lamp-shells, not related to bivalve molluscs] (chiefly productids [spiny-shelled animals] and orthids), tetracorals [cup-corals], ancient echinids [e.g., blastids, crinids, sea-lilies, etc.], and fusulinids [spindle-shaped colonial forms of protozoa with calcareous shells, often limestone makers], and the scattered trilobites [crustaceans, dominant in Cambrian times] also vanished. Their places were taken by the ammonids [cephalopods with flat spiral shells, some species having a diameter of three feet or more], lobsters, and modern echinids and molluscs. . . . By far the best sequence of American Permian formations is that of Texas, where they appear to continue the Pennsylvanian strata without a marked break. [These formations continue northward across central Oklahoma and Kansas into eastern Nebraska, as "red beds."] . . . In Texas the thickness is variable up to 5,400 feet. . . . They are vast tidal flat and river deposits of an arid climate. . . . In north-central Texas the Permian is in places replete with a wonderful array of land reptiles. The red color [denoting aridity] and the presence of gypsum and salt [Oklahoma is sometimes known as the Gypsum State] are the striking phenomena of the latest Pennsylvanian and early Permian deposits of the southwestern United States.

No rock-making records of this period are known throughout the eastern half of North America, with the exceptions of a very little fresh-water Permian deposit near Danville, Illinois, and a small brackish water area in southeastern Ohio, "as attested by the sharks of the Devonian formation." Schuchert says further (p. 432):

In the southern hemisphere, due in all probability to the cool climate brought about by the glacial period of late Lower Permian time, the more characteristic elements of the older cosmopolitan flora were in part wiped out and some of the elements which remained were evolved into new forms that soon took possession of the ancient land Gondwana, and finally of the entire southern hemisphere, including Antarctis. This plant assemblage is known as the *Glossopteris* or *Gangamopteris* flora, because of the prominence in it of these two plants. . . . It appeared about the same time in Africa, Australia, Tasmania, southern India, and South America.

Glossopteris was a Cycadophyte (pro-Angiosperm), with a net-veined (anastomosing) leaf, of lanceolate shape; *Gangamopteris* had a broader leaf (obovate form). They possessed simple fern-like fronds, and were born on creeping stems or rhizomes. *Glossopteris* was probably seed-bearing. (See E. W. Berry, "Palaeobotany: A Sketch of the Origin and Evolution of Floras," Annual Report of the Smithsonian Institution for 1918 [published in 1920], pp. 289-407). "It is not certain," says Professor Berry, "whether they were true ferns or represent the seed ferns so common in the Palaeozoic" (*Loc. cit.*, p. 383).

In the period now under consideration, one of the most important, from the standpoint of evolution, in the whole history of geology,

Gondwanaland, as we have just seen, made of a great part of the southern hemisphere one vast continent, though in early Permian time the shallow epeiric seas isolated certain regions—including, for a time at least, South America. But, as previously stated, the widespread deposits of Permian age having the *Gangamopteris* flora, which occurs throughout the southern hemisphere, indicates (as paleobotanists truly hold) that this flora could have been so widely distributed only across a continuous land, or transverse continent reaching from South America to Australia (and to the Antarctic) [?]. Schuchert says (*Op. cit.*, p. 430):

> Belief in the existence of Gondwana is widespread among European geologists, but some American workers do not yet believe in it, mainly because they hold strongly to the theory of the permanence of the oceanic basins and continents. Without this continent, on the other hand, paleontologists cannot explain the known distribution of Permian land life, and, further, its presence is equally necessary for the interpretation of the peculiar distribution of marine faunas beginning certainly with the Devonian and ending in the Jurassic.

In the second edition (1929) of his great treatise on "The Earth, Its Origin, History, and Physical Constitution," Dr. Harold Jeffreys, of Cambridge University, England, discusses, not Gondwanaland in particular, but "land bridges" in general, connecting continents, "largely to provide routes of migration for animals and plants." The waning popularity of this theory, he thinks, is due to the newer conception of (A. Wegener's) floating continents, or "continental drift." Commenting on these theories, this eminent geophysicist says (p. 306):

> The main objection to the theory of former land bridges, which have sunk below the sea, is an apparent conflict with isostasy [to be explained later], which would be serious if we were restricted to two materials [constituting the earth's crust] each capable of only one physical state, for then the quantity of the lighter material per unit area would definitely determine the elevation of the land surface, and serious change in the height of the land on a continental scale would be very difficult to explain. But when we have three materials, probably each capable of a vitreous state and at least one crystalline one, the question is on a very different footing.

(The great Swiss geologist, Eduard Suess (1831-1914)—famous as author of the "monumental treatise," "The Face of the Earth"—assumed only two materials, "Sal" (modified to "Sial" by later writers) and "Sima," dense, basaltic magmas, each capable of only one physical state.)

Under the physical conditions postulated by Jeffreys, the foundering of a land bridge could occur without departure from isostasy (Greek, *isos,* equal, and *stasis,* condition)—a term invented by C. E. Dutton in 1889. He defined isostasy as "the tendency to maintain mountain profiles in equilibrium." As early as 1855, J. H. Pratt noted a defect in mass in the Himalaya range, through observations on the deflection of the pendulum from the vertical, and an excess of mass toward the Indian Ocean; and he concluded that highlands, including both mountains and plateaus, were upheld by differences in the density of the crust. More recent investigations, especially those now being carried on by Dr. F. A.

Vening Meinesz, of the Geodetic Commission of Holland, using a submarine as a floating gravity observatory, and employing three pendulums instead of a single one, in general confirm by experimental records the theory of isostasy, by which the crust of the earth is supposed to consist of masses of varying densities, floating on a more or less fluid mass beneath.

To quote an article in *The Scientific American* for March, 1929:

"It is assumed, on the theory of isostasy, that the continents were held at high altitudes because the earth's materials under them are light —just as the ice of the lower part of an iceberg holds its top out of the water. It is also assumed that the bottoms of the oceans were underlaid by material heavy enough to hold down the ocean basins.

"Computations based on this theory, were made which showed that the assumptions are substantially true, and that these light and heavy materials extend to a depth of about 60 miles below sea level. . . . Dr. Meinesz' gravity work at sea is designed primarily to test the isostatic condition of the earth's crust below the oceans. His data will also be used to make a better determination of the shape of the sea level surface of the earth, that is, the earth's 'figure'.

"The results of his observations lead us to the conclusion that the isostatic condition exists under the oceans to about the same degree that it does under the continents. It may, therefore, now be asserted that the earth's crust is in isostatic equilibrium. It would remain so were it not for disturbing influences, the most important of which is the erosion of material from land areas, and its transportation by streams and rivers to the margins of oceans and inland seas, where it is deposited in vast quantities. This transfer disturbs the equilibrium. The crust sinks down under the sediments and it rises up under the areas of erosion. In order that this may be, the sub-crustal material must be plastic to forces acting for hundreds or thousands of years. This must be so since isostatic equilibrium exists."

For example, if oil and water are balanced in a U-tube, it is evident that, since water is the heavier, its surface will be lower than that of the lighter oil. It is upon this principle that the theory of isostasy is based. Dr. Meinesz has already (1929) observed at about 250 places, thus making it possible to show that the ocean basins are depressed by the greater density of the crustal material underneath them.

If the theory of isostasy is valid, then each segment of the earth—which may be regarded as a mosaic of great polygonal blocks—having an equal area of surface, with its apex at the center, contains the same amount of material, which it is impossible materially to increase or decrease. As Prof. H. F. Cleland very succinctly puts it ("Geology," p. 367):

When a large quantity of material is removed from the land by erosion and deposited in the ocean by streams, the increased weight under the ocean and the decrease under the mountains will cause the rock at a great depth [about 60 miles] to flow from the area which is more heavily weighted, to that from which the

weight has been removed, and the approximate equality of material in the segments will thus be restored. As the oceanic and continental segments are drawn toward the center of the earth, the surface portions are subjected to great lateral pressure produced by the crowding of the segments against one another, and since the pressure cannot be relieved by the transfer of material by rock flowage such as is possible at great depths, it is relieved by folding and thrust faulting. . . . The folding of strata by lateral pressure could not [on the theory of isostasy] cause the elevation of a mountain range *without the aid of the expansion of the material* of which it is composed, since otherwise the *quantity* of material in the segment would be increased by folding and this added weight would cause a slow sinking, and material would flow from below the heavier segment to the lighter one, until the two balanced.

The gravity data now being rapidly accumulated by Dr. Meinesz and his associates enable geophysicists to determine by an indirect method the difference in weight or mass of one part of the earth's crust as compared with other parts—whether one unit prism or "block" is heavier or lighter than some other one.

Science Service made a most interesting report on the work quite recently carried out by Dr. Meinesz, in association with Dr. F. E. Wright and E. B. Colline, of the Navy Department. A portion of this account follows:

They found a departure of equilibrium in certain regions, which reveal stresses in the ocean bottom or in the subcrustal layers. One of these regions is the central part of the Gulf of Mexico. Besides that, two great ocean deeps were studied. One is the Bartlett deep, about 22,500 feet, southeast of Cuba and between that island and Jamaica. Here they had the busiest time of their trip, for in eighteen hours they made five separate dives and observations. Altogether 49 gravity observations, each requiring a separate dive, were made. The Bartlett deep, however, rather unexpectedly showed no great stresses.

North of Porto Rico they studied the Nares deep, which showed great stresses at work. In the deep itself, the sides of which slope as much as 40 degrees in some cases, there was a deficiency of gravity, while to the south there was an excess. Dr. Venning-Meinesz thinks that this indicates that there is a horizontal pressure in a north and south direction in the ocean bottom in this region. This pressure causes a buckling, pushing Porto Rico up, and the deep down. The observations show that this pressure extends to even as far as East Cuba, i.e., much farther than the configuration of the ocean floor indicates.

From their studies in the Gulf of Mexico, off the delta of the Mississippi, they found no evidence that the large masses which the river is continually depositing on the ocean bottom disturbed the equilibrium. Apparently as fast as this deposit is laid down, the adjustments take place.

When the computation of the results is complete, some new light may also be shed on Wegener's theory that North and South America and Europe and Africa were originally joined, but that the western continent is floating away from the eastern. In his previous observations Dr. Venning-Meinesz found an excess of gravity off the Pacific shore of Central America, which might furnish an indication that the Americas were pushing westwards. This would be in accord with Wegener's ideas. Now during this expedition, observations were made off the Atlantic coast. If these prove that there is a deficiency of gravity in this region, it would be in accord with this theory, for it would show a pull, instead of a pressure, on the bottom. If it proves that gravity is in excess here also, however, the theory will get no confirmation.

(Isostasy is discussed by Jeffreys in the work cited; see Chap. ix, pp. 109-110, especially. A far more satisfactory discussion, for the

layman, may be found in the Annual Report of the Smithsonian Institution for the year ending June 30, 1921. The study is by Dr. William Bowie, Chief of the Division of Geodosy, U. S. Coast and Geodetic Survey, and is entitled, "The Yielding of the Earth's Crust," pp. 235-247. The contribution is illustrated by diagrams which make it easy for the layman to understand the rather complex theory of isostasy.)

It should be understood, of course, that not all geophysicists and geologists agree as to the interpretation of the data at present available. Even now nobody knows for a certainty exactly what the conditions are —or have been—in the depths of the earth's crust. The consequence is, as Jeffreys admits, "a change of state in the lower layer seems to admit a great variety of hypotheses." The successive rising and submerging of Gondwanaland, or of any land bridge, must therefore be admitted as a *possibility* from the viewpoint of geophysics and geology. Nevertheless, Jeffreys, with laudable caution, says, "I do not actively advocate any of them" (the various hypotheses). But when we come to the reason given for his precaution on the question of land bridges, we are somewhat astonished. Not because the famous Cambridge scientist explains that he is "not yet convinced of the cogency of the paleontological evidence," but because he clearly shows in the succeeding statement that he does not know what the paleontological evidence is! Any college text-book on geology would provide him with this evidence—especially the Pirsson and Schuchert "Text-Book of Geology" (second edition of Vol. II, 1924). So, "stepping out of character," as the stage folk say, Jeffreys tells us (not being well versed in paleontology): "The species concerned are plants and low animals, and it seems far from impossible that spores, seeds, or eggs could have drifted across [the oceans] on floating refuse."

The idea of Jeffreys' seems to be founded on a rather dim memory of Darwin's wonderful chapter on "Geographical Distribution" (Chapter XI, "Origin of Species"), where he treats, in one passage, of what he says may properly be called "occasional means of distribution." The great British naturalist and experimenter then goes on to describe "a few experiments" carried on "with Mr. Berkeley's aid," since it was not at that time known "how far seeds could resist the injurious action of sea-water." Darwin took into account the known velocity of ocean currents (derived from Johnston's "Physical Atlas"), ranging from 33 to 60 miles "per diem," and the subsequent experiments of M. Martens (which showed that 18/98 of his seeds floated for 42 days, "and were then capable of germination"), and the part that might be played by seeds transported by drift timber, and by living birds, and that seeds could, in one way or another, be "blown by gales to vast distances across the ocean." Icebergs also, he found, could transport viable seeds.

But Darwin did not doubt, on the scant evidence available to him on this point in 1859 (year of publication of "The Origin"), that land bridges existed in ancient epochs connecting continental areas. He said:

No geologist will dispute that great mutations of level have occurred within the period of existing organisms. Edward Forbes insisted that all the islands in the Atlantic must recently have been connected with Europe or Africa, and Europe

likewise with America. Other authors have thus hypothetically bridged over every ocean, and have united almost every island to some mainland. . . . This view cuts the Gordian knot of the dispersal of the same species to the most distant points, and removes many a difficulty.

Nevertheless, Darwin was not ready to accept the conclusion of some other naturalists that "such enormous geographical changes" had occurred "within the period of existing species." But he freely admitted that the available evidence pointed strongly to

the former existence of many islands, now buried beneath the sea, which may have served as halting places for plants and many animals during their migration. In the coral-producing oceans such sunken islands are now marked by rings of coral or atolls standing over them. Whenever it is fully admitted, as I believe it will some day be, that each species has proceeded from a single birthplace, and when in the course of time we know something definite about the means of distribution, we shall be enabled to speculate with security on the former extension of the land.

The data that were missing in 1859 have since largely been supplied by the researches of workers in nearly all parts of the world. Were Darwin living today, there can be little doubt that he would accept Gondwana as a once-existent continent of vast extent, capable of explaining fully the distribution of animals and plants of long ago—at least down to the beginning of Triassic time, and, quite probably, Jurassic. "The species concerned are plants and low animals," says Jeffreys. Is a camel a "low animal"? Or a rhinoceros, or an elephant? Yet Jeffreys must know that members of the Camelidae (family) originated in North America in the Tertiary (probably the Eocene period), and subsequently migrated to South America and to Asia; and that, on the contrary, the order Proboscidea (e. g., Moeritherium, Palaeomastodon, Tetrahelodon, Elephas) originated in Africa, and subsequently reached the New World, as did also the family Rhinocerotidae, numerous branches and species of which have been preserved in the Oligocene and Miocene periods (some 50 million years ago). Did they swim the Atlantic (along with innumerable other mammalian families), or was there some sort of land bridge, connecting, as must have been the case, Europe, Africa, and Asia? Had Darwin known, as we know today, of the many families and orders of African, Asiatic, and European migrants into and away from America —apparently as late as Pleistocene time—he would doubtless have believed in land connections during the history of species, or at least of genera, of his own day. Just what Jeffreys had in mind when speaking of "low animals" only, as affecting the problem of land elevation or subsidence it is difficult to conceive. However, Dr. Jeffreys is not a paleontologist, and may well rest content with being one of the world's greatest living geophysicists and cosmogonists. (See Little Blue Book No. 1326, "Origin of the Solar System," by Maynard Shipley.)

CHAPTER IV

WEGENER'S THEORY OF DRIFTING CONTINENTS

ONE of the very interesting hypotheses recently advanced to account for many known facts, including the geographical distribution of plants and animals, is Prof. Alfred Wegener's theory of continental drift. While a full discussion of this hypothesis would be out of place in this volume, a few explanatory remarks may be appropriate from the viewpoint of the evolutionist.

As long ago as 1910, F. B. Taylor, an American geologist, asked the question, "Are the continents adrift?" He seemed inclined to think they were, but his argument in support of his views did not receive the assent of his colleagues. But when, at about the same time, the same interesting question was raised and answered by so eminent a scientist as Professor Wegener, of the University of Gratz, Austria, his apparently cogent treatment of the subject made many converts to his view in Europe, and a few, at least, in the United States.

By 1925, three editions of Wegener's "The Origin of Continents and Oceans" had been issued in Germany, and in that year it was translated into English by J. G. A. Skerl. According to Wegener, North and South America, Europe, Africa, and Asia were once a single land body. The most abundant constituent of the earth is silica (the stuff that flint is made of); and, says Wegener, the continents are rigid blocks, mostly of silica. These blocks (or continents) are now floating like icebergs in a tideless sea of matter, composed largely of silica and magnesia. Owing to the rotation of the earth on its axis, the continuous mass split, and the rift that resulted became the Atlantic Ocean. The time of occurrence of the rift was during the Mesozoic era, according to Wegener, which he placed about 40,000,000 years ago—or about 200,000,000 years ago according to the geological time chart adopted in this series of books (based on the uranium-lead-helium content of the various strata of the earth's crust).

As supporting evidence, among many other factors, Wegener claims that the northeastern border of South America is shaped to fit fairly accurately into the great re-entrant angle of western Africa. Moreover, according to Wegener,

> south of these two corresponding points, every projection on the Brazilian side corresponds to a similarly shaped bay in the African, and conversely each indentation in the Brazilian coast has a complementary protuberance on the African.

Furthermore, if North and South America were pushed eastward against Europe and Africa, respectively, the Atlantic Ocean would be very effectively closed throughout.

As the Americas drifted slowly to the west, the Atlantic basin came into existence. To quote a very satisfactory review of the book, by Dr. C. R. Longwell, of Yale University, which appeared in the *Saturday Review of Literature,* at the time of its translation:

> The movement of South America started first, in Cretaceous time, whereas complete separation of North America came in a much later geologic period. Greenland and Iceland have trailed behind the main continental base. Similarly, Australia has been outstripped in the general westward-drift, and has in turn pulled away from New Zealand. India, which formerly lay beside Madagascar, has moved far to the north and relatively eastward. Eurasia and Africa have been crushed together, crumpling the coast to form the Alps and other Mediterranean mountains. The Andes and the North American Cordillera have been folded up, due to resistance encountered in the westward progress of the American continents.
>
> Seeking tests for his "displacement theory," Wegener finds that pre-Mesozoic mountain chains with east-west trend correspond on opposite sides of the Atlantic. For example, the Cape Mountains of South Africa have a logical westward prolongation in a folded chain of the same age and trend near Buenos Aires; and the Appalachian structure lines, broken off abruptly in Nova Scotia and Newfoundland, match exactly the Armorican folds in Brittany and southern Ireland. . . .
>
> Land masses consist essentially of light granitic material, *sial* (silicon and aluminum), floating high in a substratum of heavier basaltic rock, *sima* (silicon and magnesium). Under any continuous stress the *sima* is supposed to yield like a viscous fluid. On the rotating earth, bodies that float above the general level are subject to a small force acting toward the equator, and tidal attraction by the moon and sun exerts a constant pull toward the west. Wegener believes these tiny stresses, working steadily for geologic ages, are sufficient to cause slow continental movements, although he admits frankly that they appear to be incapable of building mountains like the Alps and Himalayas. He does not attempt to explain why some continents drift faster than others, or why the Americas ever broke away from Africa and Europe.

Wegener accounts for the Permian glaciation in several parts of the southern hemisphere by changes in the polar axis with regard to the land, South America, South Africa, part of India, and Australia being, he supposes, united, meeting somewhere in the South Indian Ocean. "The presence of a glacial flora in all these places at that time is then explained by the *ad hoc* hypothesis that the south pole was near the junction" (Jeffreys, *Op. cit.*, pp. 330-331). But Lake (*Geographical Journal,* 1923) points out that a similar glaciation took place at this time in Northern Baluchistan, which, as Jeffreys remarks, would, on Wegener's hypothesis, have been practically on the equator; while C. E. P. Brooks ("Climate through the Ages," 1926) calls attention to the curious distribution of climate in North America at the time, which, says Jeffreys, "is inexplicable on Wegener's views, but is reconcilable with the earlier geological ideas of land connections."

The Wegener theory (or hypothesis?) gained the support of Pierre Termier, the distinguished French geologist and oceanographer. In an address at the *Institut océanographique* of Paris (published in the *Revue Scientifique,* May 10, 1924), Dr. Termier referred approvingly to the eminent Austrian geophysicist "who uprooted the continents and compared them to pontoons floating to a port," or, "better still, to icebergs." He told his hearers at the *Institut* (founded by the generous and scientifically-minded late Prince Albert I of Monaco) that, in his opinion, the chains of islands

are comparable to the small icebergs which break off on the edges from the great mountains of ice and remain behind, being more retarded in the intervening waters on account of their small sizes. The islands form a group of stragglers behind a continent which advances. Consider the insular areas of eastern Asia, the Aleutian Islands, the peninsula of Kamchatka, Kurile, Sakhalin, Japan, Liu-Kiu, Formosa, Philippines, and Borneo; are not these fragments of the Asiatic coast detached nearly simultaneously and showing, by their arrangement in garlands parallel to the outlines of the shores, that they formerly belonged to them? And the chain Sumatra, Java, Sumbawa, Flores, Timor, what is it, except a truncated extension of this tail of Asia, the Malay Peninsula? The sections of the Asiatic tail follow the general movement of Asia but with a slight retardation. What are the Antilles if not fragments large and small of Central America left behind, the little ones more retarded than the large ones and forming a flotilla whose center advances less rapidly than its wings and which incurves thus to the form of a semicircle open to the west? And what do we see at the southern extremity of South America? The point of the continent twisted toward the east, twisted at right angles, then at Cape Horn, and in Staten Island abruptly broken; but a little further to the east there are the remains of this point—South Georgia, South Shetland, South Orkney, Sandwich Group, all one series of wreckage, outlining another incurved flotilla whose left wing almost touches the point of the Antarctic, which point twists toward the east, as does the American point which faces it across Drake Strait. Does not this disposition in semicircles of the two points and of the archipelagoes cause one to vision the rupture of an old bridge which should have joined the Antarctic to South America and which, being without doubt too thin to resist the thrust of the marine depths opposed to its drifting toward the west, would have twisted its two abutments, and not being able to rest entirely coherent after twisting, would have broken in disjointed groups of scattered masses?

Finally, let us consider Australia. Above is New Guinea, which seems to be only a detached portion; above and to the right of New Guinea a whole chain of islands, which curve toward the south parallel to the Australian coast including New Caledonia and farther New Zealand. Does it not seem to you that this chain of islands joins from the north of New Guinea to that of the Malay Archipelago which I called, a minute ago, the truncated tail of Asia? The joining takes place in the region of the Molluca and the Celebes, where the archipelagoes twist around confusedly But would not this twisting be due to the advance from south to north of the enormous mass of New Guinea-Australia? Would not these sections of the Asiatic tail formerly extending toward the southeast, as Sumatra, have been deviated toward the north by the drifting of Australia?

In his delightful and beautifully illustrated popular book on geology, "This Puzzling Planet" (1928), Edwin Tenney Brewster sums up the evidence offered in support of the theory of continental drift, and concedes that the continents, consisting of relatively light rocks about 40 miles thick, may be attached to an underlying mass of crystallized basalt, frozen on to the under-side of the granitic crust, and in turn floating on an uncrystallized basaltic glass, "very hot, but kept solid by the enormous pressure of the forty-odd miles of rock over it" (p. 164). He finds

not a little reason for thinking that the uniform width of the Atlantic and the remarkable fit between its two sides is something more than an accident. [Be this as it may, our modern plants] appeared so nearly at the same time on both sides of the North Atlantic that it is not certainly known where they first arose. So there must either have been a long bridge, which is now broken apart, from Europe across to America by way of Iceland and Greenland, or else North America and Europe must have been one land-mass.

Brewster cites the very suggestive fact that the coal of Pennsylvania, New England, and Nova Scotia is of the same age as that of the British Isles, France, Germany, and Spain, and "is altogether very much like

it." On the other hand, "rocks of the Coal Period in Africa contain no coal at all." He feels that these facts point to a time, the coal-forming period, when there existed a single great coal-field "that has since cracked apart." He presents geological evidences to show that a continent once lay where the North Atlantic now is (pp. 169-170), and adduces many exceedingly interesting points in support of Wegener's bold hypothesis.

Dr. Jeffreys, on the other hand, contends that the several mechanical forces suggested by Wegener to produce the postulated continental drift are inadequate. He says (*Op. cit.*, p. 322):

> To make America move westwards with respect to the old World, as is required by the theory, a westerly force is required; the only one known is tidal friction, which is on an average under 10^{7} of the equatorial drift, and therefore at the most favorable estimate would take 10^{17} years to produce the desired effect. To produce the effect in 3×10^{7} years we require a westerly force 10^{10} times as potent as tidal friction. But tidal friction is not an insignificant force; it has altered the earth's rate of rotation very considerably during its history, and probably during geologic time. It appears that such an external force as the modified theory would require would stop the earth's rotation in a time of the order of a year.

He attacks, also, the alleged fit of South America in the angle of Africa, a "fit" which is, in reality, a misfit of about 15°.

> The coasts along the arms of the angle could not be brought within several hundreds of kilometers of each other without distortion. The widths of the shallow margins of the ocean near the continents lend no support to the idea that the forms have been altered considerably by denudation and redeposition; and if the forms had been altered by folding there would be great mountain ranges at a distance from the angles with their axes pointing towards the angles, which is not the case. (The Brazilian Heights are greatest *near* the angle, where the distortion required is least.) Similar misfits are encountered in comparing North America with Europe. [See P. Lake, *Geological Magazine, 59,* 338-346, 1922; *Geographical Journal, 61,* 179-187, 1923.] A petrological comparison of the regions alleged to have been in contact leads to a further set of inconsistencies [as shown by H. S. Washington, *Journal of the Washington Academy of Science, 13,* pp. 339-347, 1923]. . . . But reference must be made to the assertion that the situation of the Rocky Mountains and the Andes is what would be expected on the theory of continental drift. On the contrary, it is one of the most definite pieces of evidence against it. Either the materials of the ocean floor are stronger than those of the continents, or they are weaker. If they are stronger they will not give way to let the continents move through them; if they are weaker, the continents would advance, if at all, without being fractured, and no mountains would be formed.

But I need not pursue this problem further here, as it must be taken up again in connection with geographical distribution in Vol. VIII of this series. The reader who is especially interested in this fascinating subject may consult the symposium on "The Theory of Continental Drift," published by the American Association of Petroleum Geologists, Tulsa, Oklahoma, to which fourteen of the world's greatest geophysicists and geologists have contributed, including Wegener, Schuchert, John Joly, Edward W. Berry, and other equally eminent experts.

CHAPTER V

THE EVOLUTION OF REPTILES

AT the close of the Carboniferous era, when the Permian rocks were laid down as sediments on the Pennsylvanian, the far-reaching seas of the latter had withdrawn, a long period of land-elevation and aridity following. The Permian may be considered as a transition period between the Palaeozoic and the Mesozoic. It is interesting to note that, in the eastern United States, the plant remains of the Permian more closely resemble European plants than they resemble those of the underlying Pennsylvanian. Gondwana still broadly connected South America with the Old World, including Australia, New Guinea, Tasmania, and New Zealand. Siberia, Alaska, Canada, Greenland, and Iceland formed a vast land connection with Europe, Asia, and Africa.

Over large areas of the earth's surface deserts existed in the Lower Permian, as the ripple-marked and sun-cracked red sandstones and shale and the interbedded salt and gypsum testify. Central and western Europe, England, and western North America are known to have been so affected (H. F. Cleland, "Geology: Physical and Historical," p. 477).

Reptiles now gained ascendancy over the previously dominant amphibians, which have occupied a very subordinate place since the Triassic, which followed the Permian period. Osborn says (*Op. cit.*, pp. 184-186):

The experiments of the Amphibia in adapting themselves to the Permian continents, with their relatively dry surfaces and seasonal water pools and lagoons, are contemporaneous with the first terrestrial experiments and adaptive radiations of the Reptilia, a group which was particularly favored in its origin by arid environmental conditions. The result is the creation in Permian time of many externally analogous or convergent groups of amphibians and reptiles which in external appearance are difficult to distinguish. Yet as divergent from the primitive salamander-like Amphibia, and clearly of another type; these pro-reptiles are different in the inner skeletal structure and in the anatomy of the skull; they are exclusively air-breathing, primarily terrestrial in habit rather than terrestri-aquatic, superior in their nervous reactions and in the development of all the sensory organs, and have a more highly perfected cold-blooded circulatory system. Nevertheless, the most ancient solid-headed reptilian skull type (Cotylosauria [amphibian-like reptiles], Pareiasauria [massive herbivorous reptiles] of Texas and South Africa, respectively) is very similar to that of the solid-headed Amphibia (Stegocephalia) [all leading back, as previously remarked, to the skull type of the fringe-finned ganoids (Crossopterygia)].

Osborn further tells us that the primitive reptile *Varanops*, a lizard-like polycosaur, with a long tail and four limbs of equal proportions, "represents more nearly than any known ancient reptile, apart from certain special characters, a generalized prototype from which all the

eighteen Orders of the Reptilia might have descended; its structure could well be ancestral to that of the lizards, the alligators, and the dinosaurs." However, he does not attempt to determine "whether the primitive ancestors from which the various orders of reptiles have descended belong to a single, a double, or a multiple stock" (*Op. cit.*, pp 186-187).

Williston was quite certain that the reptiles arose not later in geological history than the Lower Carboniferous (Mississippian time), from a generalized type which he called, provisionally, Protopoda, a form ancestral to both Amphibia and Reptilia. "Both classes have advanced since their divergence, the Amphibia some [*sic*], the Reptilia much." Some of the footprints of the Lower Carboniferous, he conjectured, may be of this postulated transition from Protopoda.

Schuchert thinks it probable that the Reptilia arose earlier than the earliest Pennsylvanian time,

for in the latter part of this period occurred not only true reptiles but also highly specialized forms. From the Pennsylvanian and older Permian of Texas, Oklahoma, and New Mexico, Williston and Case have made us acquainted with many different kinds of primitive Amphibia, and associated with them is even a greater and more complex society of primitive Reptilia, animals that attained a maximum length of eight feet (*Op. cit.*, pp. 416-417).

Prof. E. C. Case, of the University of Michigan, has made an exhaustive study of "The Permo-Carboniferous Red Beds of North America and their Vertebrate Fauna" (Publications of the Carnegie Institution, No. 207), and of "The Environment of Vertebrate Life in the Late Palaeozoic in North America: A Palaeographic Study" (Publications of the Carnegie Institution, No. 283). In the latter monograph Dr. Case has laid great emphasis on the meaning of the sediments and sedimentary changes in terms of the causes which would affect the vertebrate life of the time.

Although the first adequate collections of vertebrate fossils have been made from the rocks of the upper half of the Pennsylvanian period, the description and discussion of certain areas is begun from stages as early as the Allegheny in order to trace the sequence of significant events.

The conclusion is reached that the "red-bed conditions," under which the vertebrate life had its main development, were initiated by a slow uplift of the continent, beginning on the eastern side (where it is evidenced in places by true glacial conditions) and progressing slowly toward the west. "Red-bed conditions" are thus found to occur at successively higher levels from east to west, largely independent of other depositional conditions. Correlation of the environmental conditions grouped under the caption "red-bed conditions" is accomplished by the recognition of distinct characters which are the direct result of an advancing wave of climatic change and such conditions are recognized as a distinct environmental unit, independent of, and in many cases distinct from, stratigraphic (time) units, which compelled the existence of a distinct and uniform type of life.

From the studies of Case, R. L. Moodie, and other eminent investigators, it is not certain that the Permian reptiles of North America were descendants from the African forms, arriving here as immigrants, though they had some 20,000,000 years in which to make the journey! But any other hypothesis might, perhaps, raise more difficulties than it would

solve. At all events, it is in South Africa that the development of mammal-like reptiles is in full evidence. .Here we come to grip with facts, not theories only—though there are no *theories* not based upon observed facts, in science. A theory may, however, be well founded so far as the facts are known, but become untenable in the light of fresh and highly important additional knowledge. Inferences based upon admittedly inadequate data are not properly termed "theories," but "hypotheses." The latter may rise to the dignity of theories by the accumulation and correct interpretation of new and accordant discoveries. We are fully justified by the abundant facts now at hand in the rational conclusion that mammals descended from some such type of mammal-like reptiles as have been found in the rocks of South Africa.

The discovery of pro-mammalian types of reptiles (cynodont, theriodont) in South Africa, with a number of mammalian features, has completely upset the older theory, based entirely upon anatomy, that the Mammalia arose directly from the amphibians—a view adopted, among other famous scientists, by Huxley, Perrier, LeConte, and Prof. J. M. Macfarlane, of the University of Pennsylvania (who still adheres to this view, and ably defends it in his "Causes and Course of Organic Evolution.")

In his Presidential Address delivered before the Paleontological Society, December 29, 1922 (*Bulletin of the Geological Society of America,* Vol. 34, September 30, 1923), Prof. William Diller Matthew, then curator-in-chief, Division I, of the American Museum of Natural History (now at the University of California), stated some facts which should be of particular value to readers of the older writers on evolution.

He remarked, in effect, that much of the older research in vertebrate paleontology was by men who were primarily comparative anatomists rather than geologists. This was partly due to the circumstance that the fossils known to them were relatively few and more often than not, fragmentary. Their preoccupation with comparative osteology, necessary as such study was—and still is, for that matter—led to a tendency to overemphasize the anatomist's viewpoint, hence to attach too much value to the study of the evolution of *structures,* and not enough to investigation of the *actual sequence in time of the animals themselves.* More careful stratigraphic studies have enabled our more modern experts to define horizons, and faunal zones, in much more precise and nearly correct detail. With the far larger collections of today, about 90 percent of which is the product of the past 35 years of research, the records are quite adequate to trace in many cases the *evolution of species* and not merely of *structures.*

The earlier writers on evolution did not attempt this. Gaudry and Haeckel, Rutimeyer and Kowalewsky, Huxley and Cope, demonstrated from the paleontological record the evolution of structure. Depéret and Schlosser, Osborn and Scott, and many others have perceived and pointed out this weakness in our evidence and have attempted to trace the true phyla.

Emphasis is now placed on the veritable records of the phyletic history of races of animals. Prof. Thomas Hunt Morgan's strictures on

paleontological evolution, in which he declared that paleontologists had no business to reason on or draw conclusions from their specimens (in his work of 1916, "A Critique of the Theory of Evolution," pp. 24-27), are no longer justified—if they ever were. However, they were aimed solely at the old methods, and are not applicable to the work of today in this broad field of labor.

Here, to illustrate the closeness of the primitive mammals to reptiles, should be mentioned *Tritylodon longoevus*, whose skull, from the Triassic of South Africa, was originally described by Owen and classed by him as belonging to a theromorphous (mammal-like) reptile, and which was carefully studied anew by Dr. Branislaw Petronievics, and classed by him as "the most primitive of known mammals." This fossil, he contends, affords "direct proof that the mammals have their origin in reptiles" (*Ann. and Mag. Nat. Hist.*, pp. 67-69, 1918). Its mammalian characters, he insists, are beyond dispute, and "it can no longer be regarded as a theromorphous reptile." (This now famous skull is preserved in the Museum of Practical Geology in London.)

The late Prof. S. W. Williston, of the University of Chicago, gave it as his matured judgment that

> The change from amphibians to reptiles was gradual, and we know so many connecting links between the two classes that it is sometimes hard to decide to which class some of them belong. The reptiles began as small creatures, descended from the less specialized amphibians long before the latter had reached the zenith of their evolution.

(Williston produced numerous contributions on this phase of our subject, mostly to be found in *The Journal of Geology*, 1908 to 1918. See, also, his book of 1911, "American Permian Vertebrates," and "The Osteology of the Reptiles," 1925.)

In the character of the vertebrae (amphicoelous), which are hollow at both ends, and in some cases only partly connected with bone, the *Theromorpha* (mammal-like reptiles) connect with amphibians; while in the limbs and especially the teeth of certain genera, e. g., the *Cynognathus* (Order Therapeida=Theromorpha) of the Triassic, with their dog-like teeth, including incisors, canines, and molars, they lead unmistakably to the mammals. The dentition of some species, e. g., *Inostranservia, Scymnognathus*, reminds us strongly of the dog, or even of the saber-tooth tiger. The tuberculation of the molars characteristic of mammals had already commenced. However, the adjustment of the lower jaw is typically saurian in nearly all the Theromorpha, and it is probable that the ancestral transition form will be found in a more remote group, more nearly resembling the present-day amphibian newts, with a lower jaw so generalized that it might develop in the style of a genuine reptile or into the other extreme of the genuine mammal.

But we shall see that Broom has solved this problem for *Cynognathus*.

Prof. Richard Swann Lull, of Yale University, in his "Organic Evolution," says:

Structurally the cynodonts bridge the gap between reptiles and mammals because, while the dentary, the single bone of the mammalian lower jaw, is large and important, the jaw is nevertheless complex in that it possesses the several bones typical of the reptile.

Two decades ago, anatomists found great difficulty in accounting for the squamosal-dentary joint of mammals; i. e., how the quadra-articular joint of reptiles gave rise to the structure of the jaw peculiar to mammals. This problem was solved by Dr. Robert Broom, then professor of geology and zoology at Victoria College, Stallenbosch, South Africa, in 1912. He showed that in one (*Cynognathus*) of the many mammal-like reptiles whose fossil remains have been found in the shales (Karoo formation) of South Africa, a considerable part of the articular surface of the single bone (in mammals) which forms the lower jaw, or dentary, is formed by the squamosal, and that the posterior end of the dentary merely takes part in the joint. The dentary develops an uprising "coronoid process" which touches the squamosal, and so takes on the function of articulating the lower onto the upper jaw. Broom pointed out that as the direct articulation of the dentary on the squamosal became more firmly established the quadrate, articular, and angular, present in all lower forms, fell into disuse, degenerated, and might have been lost had not the attachment of the stapes (stirrup) to the quadrate compelled them to take on an auditory function, the quadrate becoming the incus, as can be shown by the embryological development; the articular becoming the malleus; and the angular becoming the tympanic bone (or membrane) all parts of the ear (R. Broom, "Mammalian Auditory Ossicles," *Proceedings of the Zoological Society*, 1912). Professor C. Tate Reagan, of the Natural History Museum, London, states emphatically that "the vexed question of the homology of the mammalian auditory ossicles may be regarded as settled, palcontology confirming the conclusions derived from embryology."

It is indeed, as Prof. G. R. deBeer remarks, "a striking fact that the mammalian ear is associated with bones which in the ancestors served to form the articulation between the upper and lower jaws." However, as he remarks further ("Vertebrate Zoology," pp. 298-299):

The remarkable change of function which these bones have undergone is less remarkable than would appear at first sight, for their essential feature is that they remain articulated to one another, and so are able to transmit the vibrations of sound. The *columella auris* [a slender rod which connects the ear-drum or tympanic membrane with the *fenestra ovalis*, a small opening between the tympanum and the internal ear or vestibula, in the side of the auditory capsule] is pierced by an artery and resembles the stapes in certain lizards and Gymnophiona [Apoda or Caecilians —limbless Amphibia], and in the latter group of animals it may be connected with the quadrata. There is therefore no radical innovation in the fact that the incus articulates with the stapes. . . . The most remarkable feature of this change is the fact that it was effected without functional discontinuity.

We must pass now to a kind of modification which is still more remarkable—involving a much greater change of function in its ultimate development in the Mammalia. I refer to the pineal eyes that were to evolve into so important a "ductless gland" in Man, serving not at all as a visual organ.

Attention was called to the pineal and parapineal eyes in the roof of the brain of the Petromyzon (lamprey). In the Reptilia these eyes, as such, no longer exist. But in Sphenodon and the Stegocephalian Amphibia a small orifice through the bone over the brain still persists. In the Reptilia the skull aperture is closed, and the transformation to the pineal gland of mammals was well on its way. Today, it has an entirely new physiological function probably affecting sexual development.

It was in Petromyzon that we first met with a "pair of pockets" ventral to the nasal cavities, and originally formed from them. Each opens into the mouth cavity a little way in front of the internal nostrils (choanae), and they are known as Jacobson's organ. There is reason to infer that they are used to smell food in the mouth, but their function is not yet certainly known. "In the snakes they are very highly developed, and the tips of the forked tongue enter their openings in the roof of the mouth" (deBeers). In some forms, including man, Jacobson's organ disappears. Broom has shown ("Organ of Jacobson in the Insectivora," *Proceedings of the Zoological Society*, 1915) that *changes in habit* bring about marked alterations in teeth, bones, and many viscera. But the delicate little cartilages in the nose are usually so little affected by change in habits that

> We find almost the same type of structure in forms so dissimilar as the sheep, cat, hedgehog, bat, and lemur [all, of course, mammals]. And as the arrangement is an extremely complicated one we seem justified in assuming that the similarity indicates affinity and common origin of these types, rather than independent developments of this remarkable structure.

It is worthy of note that whereas the fauna of the South African Permian—where we find the initial stages in the evolution of dinosaurs, birds, and mammals—is largely that of an arid region, the Texas Permian is that of a fluviatile—river-delta—or littoral—beach—facies (from the Latin, meaning face, hence, general aspect, and in biology, the general aspect or habit of a species or group of species). It should be understood, however, that much yet remains to be learned about Permian invertebrates. So far as I can learn, the Dvina River, in Poland, for example—a series of desert or plains faunas—has not been exploited since the work of Amalitzky, a quarter of a century ago; nor has anything of importance, apparently, been added to Fritsch's pioneer work in Bohemia, in a small, but perhaps rich, former swamp.

As for the Triassic Period, the least known chapter, so far as reptiles are concerned, at least, is America. Professor Matthew said in 1922—and this appears still to hold good, according to the records at my command: "What little has been accomplished in this direction is due to the energetic prospecting of Dr. Case, and contains promising prospect for the future as well as a few but very interesting additions to the Triassic faunae.".

In Europe, however, some very important discoveries have been made, especially in Germany, but these do not closely concern us in this story.

Osborn raises and answers the very natural question as to why the

dog-like or beast-like reptiles (gorganopsians) of the Karoo series of South Africa (9500 feet of strata, consisting of shales and sandstones, "chiefly of river flood-plain and delta origin, ranging in time from the basal Permian into Upper Triassic") were so highly favored as to become the potential ancestors of the mammals. The first reason he gives is that these reptiles were no longer weak and short of limb, but had developed strong limbs, raising them well above the ground, and were capable of rapid movements. This increased migratory ability, he thinks, was associated with increasing intelligence. Moreover, he notes how their teeth had varied in different directions, giving them the power to masticate various kinds of food, which naturally "leads to development and diversity of the powers of observation and choice." Ordinary reptiles are, on the contrary, distinguished by a remarkable arrest of development of the teeth. In his "Evolution of Mammalian Teeth" (1907) and "The Age of Mammals" (1910), and in "The Origin and Evolution of Life," Dr. Osborn has shown how the rapid specialization of the teeth has been one of the chief factors in the history of mammals.

Of greater importance in its influence on the brain evolution of the early pro-mammalian forms is the internal temperature change, whereby a cold-blooded, scaly reptile is transformed into a warm-blooded mammal through a change which produced the four-chambered heart and complete separation of the arterial and venous circulation. This change may have been initiated in some of the cynodonts. This new constant and higher temperature favors the nervous evolution of the mammals but has no influence whatever upon the mechanical evolution. . . . Nor does increasing intelligence . . . favor mechanical perfection. Out of the total of eighteen reptilian branches only five were destined to survive into Tertiary time, namely, the orders which include the existing turtle, tuateras, lizards, snakes, and crocodiles. . . . By methods first clearly enunciated by Huxley in 1880 several of the ideal vertebrate prototypes have been theoretically reconstructed, and in more than one instance discovery has confirmed these hypothetical reconstructions ("Origin and Evolution of Life," pp. 192-194).

CHAPTER VI

"LIVING FOSSILS"

OSBORN referred in the above paragraph to the tuateras. By a happy circumstance, a representative of this very ancient order of amphibian-like reptiles still survives in New Zealand (*Sphenodon* [*Hatteria*] *punctatum*). It is the most generalized of all living reptiles.[1] Its entire structure remains so primitive that it represents a striking illustration of the transition form from amphibian to reptile. As William Bölsche well puts it, this creature combines "the newt and the present-day lizard in an almost neutral shape." Gadow speaks of this surviving form as "the last living witness of bygone ages," a "living fossil." However, although it cannot be denied that the tuatera (the name given it by the Maoris of New Zealand) is, as Gadow says, an "almost ideally generalized type of reptile," Williston finds in the fossil *Palaeohatteria* a more nearly connecting link between amphibians and reptiles. Moreover, this great authority asserts that some of our modern lizards are even more primitive in structure than is the genus *Sphenodon*, though the tuatera is decidedly primitive in some features, especially in the skeletal structure of both limbs and girdles, and in the absence of a penis.

Sphenodon is a species, genus, family, and order all by itself. It is a reptile, but it is neither crocodile, lizard, snake, nor turtle. But, loosely speaking, it is more of a lizard than anything else. Among other very primitive features in *Sphenodon* is its surviving "third eye," or pineal organ, which is less degenerate in this than in any other living animal—not excepting *Petromyzon*, which has two pineal organs, whereas *Sphenodon* has only one, representing either the right or the left organ. The organ has lost its function as a true eye, but is still sensitive to light. In all well-preserved stegocephalian skulls (Palaeozoic Amphibia), a single small orifice through the roof bones over the brain is to be seen, representing the pineal eye. The rudiments of this eye are present in the brain of all living vertebrates, including man. Its ancestry can be traced back at least to Pennsylvanian time.

Why has *Sphenodon* outlived the dinosaur and many other prehistoric creatures which first appeared on the earth long after it? Why has it not changed or at least adapted itself, as have other old forms of life still extant? Dr. G. Kingsley Noble, Curator of Herpetology of the American Museum of Natural History, says on this point:

> *Sphenodon* still lives on Karewa because the conditions of life on that island are about the same today as they were eight million years ago. He hasn't changed in all these years because he hasn't had to change.
>
> *Sphenodon* exists today where he does simply because he is unchangeable. Life has to adapt itself to conditions. When conditions change, life adapts itself or perishes. That is what happened to the dinosaur.

He lived and flourished for millions of years. The conditions changed and he didn't. He died. No doubt *Sphenodon* died too, in other parts of the earth. We have seen him die on the larger islands of New Zealand. He wouldn't exist today on Karewa if it had changed much.

This is one of the reasons why New Zealand is even more interesting than Australia to the naturalist. It contains traces of forms of life not found elsewhere, the living forms themselves, mainly because it has not changed until quite recently. For example, until recent times *Sphenodon* had no competition with predatory animals. The greatest enemies of all the prehistoric reptiles were mammals, who first evolved, millions of years ago, as small, rat-like creatures. The record of the rocks shows that there were no mammals in New Zealand until approximately a thousand years ago—a mere moment in the history of the world. The first mammals in New Zealand were men, and rats which the men brought with them. Nor has the vegetable life of the island of Karewa changed greatly from that to which *Sphenodon* was accustomed. The great ferns and vines and thorny scrub are still there.

The Maoris have long considered the flesh of the tuatera a great delicacy, and have all but exterminated this interesting creature. Now, however, the New Zealand government has taken steps to protect it against extinction. It is feared, however, that the government has intervened too late, for as long ago as 1882 the creatures were very rare.

At one time, scientists believe, *Sphenodon* flourished all over New Zealand. But it has disappeared from the two main islands, and of late years has been found only on a group of rocky islands, none more than six acres in extent, in the Bay of Plenty on the east side of the North Island. Today they are found only on Karewa, and only one man there knows where to find them.

The late Dr. Frederic A. Lucas wrote a very interesting account of the discovery and capture of several tuateras. It is contained in the *Natural Science Bulletin*, issued in 1882 by H. A. Ward, and written by a member of a scientific expedition in New Zealand.

Sphenodon is from nine to twelve inches long. The female lays her eggs in the sand and the male fertilizes them. The sun hatches them, but it takes a year or more. One egg at a time, and perhaps a dozen in a lifetime, are all the *Sphenodon* lays.

While it is true that the generalized reptiles of the late Permian and early Triassic periods gave rise to primitive mammals, some 100 millions of years were to come and go before the "Age of Mammals" would be reached. The imagination of man staggers before these figures if an effort is made to think of them in terms of even hundreds of thousands of years. During this inconceivable length of time the first Sierra Nevada Mountains, although formed in the latter half of the era (the Jurassic), after being raised to a great height, were slowly eroded and finally washed to the sea. During even the last fourth of the era (Upper Cretaceous), 24,000 feet of sediments—almost five miles in depth—were washed away and deposited in the seas. On the eastern coast the Appalachian Mountains, which had been raised during the

closing years of the Palaeozoic, were now reduced and worn to a peneplain, worn down to a base level, as was the western range. On the other hand, it was during this long period that the Rocky Mountains of Canada and the United States had their birth. In Utah the Wasatch and Uinta Mountains, and in British Columbia the Gold Range, were raised. During this long period a number of land reptiles had taken to the sea, lost their fingers and toes, the forelegs being transformed to paddles and the hind limbs reduced and outwardly scarcely visible, as in the Ichthyosaurs. Strange to say, even a median and tail fins, similar to those of the sharks, were evolved. The time came when even a seasonal return to the land to deposit their eggs was abandoned. Says Osborn, on this point:

> A climax of imitation of the dolphins and of certain of the sharks is reached in the development of the power of viviparity, the growth of the young within the body cavity of the mother, resulting in the young ichthyosaurs being born in the water fully formed and able to take care of themselves immediately after birth like the young modern whales and dolphins. . . . So far as we know this viviparous habit was never developed among the seafaring turtles, which always return to shore to deposit their eggs.

During the Upper Cretaceous, great sea lizards (Order Mosasauria —taking its name from the River Meuse), some of which (*Tylosaurus*) were 35 feet or more in length, swarmed the Atlantic and Gulf coasts and the interior seas east of the Rockies. They were capable of making a meal of the giant *Portheus*, a predaceous fish some fifteen feet in length. Monster turtles, twelve to fourteen feet long (*Archelon*), with feet modified to form "flippers," then luxuriated in the warm waters which covered what is now western Kansas. It was in the Cretaceous chalk beds of this region that Professors Marsh, Cope, and others made their epochal discoveries. Land turtles were as yet unknown. In the air (of the Jurassic) were the pterosaurs (flying lizards), some as small as sparrows, others large, one species being the largest flying creature that ever lived, measuring over twenty feet from tip to tip of the wings. The pterosaurs are related to birds only in that both are derived from a common reptilian ancestor.

In the same seas that rolled over western Kansas swam the great toothed diving bird *Hesperornis regalis*. But this is to anticipate our study of the origin of birds from reptiles.

Long before the continental invasion of the Cretaceous Sea of Upper Mesozoic times, a wide expanse of water which united the Gulf of Mexico with the Arctic Ocean, a branch of the terrestrial saurians, the Dinosaurs, or "terrible lizards," had spread over North America from the Valley of the Connecticut to what is now the Rocky Mountain region. At that far-off time the Rocky Mountains were unborn, and what are now arid plains were then areas of luxuriant vegetation, abounding in lakes, rivers, and marshes, stretching from New Mexico to Montana. Before the close of the Mesozoic era, the bipedal Dinosaurs and the gigantic Sauropoda (unarmored quadrupeds) had spread to all the continents of the world, even to Argentina, eastern Africa, Australia and New Zealand.

It was in 1802 that we gained our first knowledge of America's "first family" of reptiles, whose fossil footprints were plowed up by farmer Pliny Moody, in the Valley of the Connecticut. They were imprinted in what is now known as the "brown stone," once the mud of a long, narrow estuary running southward from Turner's Falls, Massachusetts. They were small footprints, and might have been made by a saurian no larger than a common fowl. Indeed, being three-toed tracks, they were interpreted even by Prof. E. Hitchcock ("Ichnology of New England") as impressions of bird's feet, and were popularly called "the tracks of Noah's raven." But in 1836, the year in which Professor Hitchcock first explored these ancient mud flats, Dr. James Deane published a monograph on the subject ("Ichnographs from the Sandstone of the Connecticut River") in which it was suggested that the tracks might not have been made by birds. 1896, Prof. O. C. Marsh published his now famous Report on "The Dinosaurs of North America": and in 1915 Professor Lull made public the results of his careful study of the region.

The Dinosaurs, like the Marsupials of Australia, evolved every variety of form and size in their several adaptations, ranging from the small bipedal saurians of the Connecticut Valley in Triassic time to the ponderous *Tyrannosaurus rex* of the Upper Cretaceous of Montana, an adaptive radiation which carried them over the entire northern hemisphere, a large part of the southern hemisphere, and through a period of time as great as 150,000,000 years. During this period we note how the *Anchisaurus* of the Connecticut Valley, first described by Marsh, develops into the more powerful *Allosaurus* type of the Jurassic (Morrison) flood-plains of Wyoming and Colorado. A gradual improvement in the teeth for the tearing of flesh, and a development from ordinary claws to great talons is noticeable. Both the relatively small hands and the teeth grew in prehensile power, even the hind feet being "adapted to seizing and rapidly overcoming a struggling powerful prey" (Osborn). *Tyrannosaurus* was 47 feet long, stood 19 feet high, and possessed a terrible set of teeth which projected by the hundreds, from two to six inches from the jaw. Its biting power was 250 times that of the largest man-eating tiger, and 20,000 times that of an average man. Man's biting power is equivalent to ten pounds and that of *Tyrannosaurus* would therefore be 200,000 pounds. Like other Dinosaurs, the bones of *Tyrannosaurus* were pneumatic (hollow), and its hind legs were adapted to rapid motion. In speed, size, power, and ferocity, this veritable king of the saurians was, as Osborn well says, "the most destructive life engine which has ever evolved."

The recent discovery of a large species of anthropoid ape in the untrodden forests in the neighborhood of the Terra River, an affluent of the Rio Catatumbo, in the Motilones districts of Venezuela and Colombia, by the well known explorer, Francis de Loys, D.Sc., F.G.S. (see *The Illustrated London News*, June 15, 1929, where photographs of this strange female ape are reproduced)—a description of which will be given in the next volume of this series—reminds one of the story brought back from the Belgian Congo, in 1913, by Captains Capelle and Lepage, two Belgian naturalists. They claimed to have seen a live

Brontosaurus (thunder lizard) in Central Africa, or at least a reptile resembling this gigantic creature; and they brought home what was represented as a photograph of the footprints of the great sauropod. These footprints were four feet in diameter, and the animal appeared to weigh about forty tons.

The explorers got, so they reported, but one glimpse of its twenty-foot neck and forty-foot tail, the body being partly submerged in water. Its "wicked, snake-like head was gemmed with two large, saucer-like, phosphorescent eyes." No teeth were visible, but the creature may have had poisonous fangs, like so many other reptiles. If the beast was really thus seen for an instant, half hidden in a subterranean cave-lake, and was accurately described, it may possibly be the descendant of an enormous lizard-like creature which was previously supposed to have become extinct nearly 200 million years ago. After what has been said of the *Sphenodon*, it need not surprise us if some Mesozoic reptile were still swimming in the depths of African jungles.

The World War interrupted the explorations which Capelle and Lepage were conducting for the Belgian government; and these intrepid naturalists have not yet, so far as I know, secured the necessary financial backing to return to the scene of their very remarkable adventure. But, inspired by the hope of securing at least the hide and bones of a contemporary Brontosaurus, several other naturalists were reported to have set out for equatorial Africa in search of a specimen of this reputed "living fossil." It is significant that the Smithsonian Institution financed an African expedition, under the direction of Edward Heller, who so successfully led the Roosevelt hunting party some years ago. A press dispatch, dated in London in 1913, stated that the Smithsonian Institution had offered five million dollars for a specimen of the colossal lizard. As a matter of fact, no such fund has been provided for this special purpose. However, soon after the report of the living Dinosaur was made, Captain Leslie Stephens, backed by British capitalists, left London for the Belgian Congo in an independent attempt to reach the retreat of the reputed Brontosaurus before any American hunters could get to the region. There are other rare animals, moreover, in equatorial Africa, whose tracks have been observed, but specimens of which have never been secured; and these various expeditions or like ones may some day bring to light many surprising discoveries, apart from the supreme interest attaching to the question of the survival of a Mesozoic Dinosaur. (There have also been explorers' tales of the finding of extant Dinosaurs in South America; but they are not well enough authenticated to detail.)

Now, this monstrous creature, possibly larger than any other living animal, more gigantic even than the hugest of whales, is (if it exists), in all probability a near relative of the shy little lizard, so common in nearly all parts of North America. To find this connection, we must take a journey millions of years back into the past, to the very dawn of the "Age of Reptiles".

During the earlier stages of the "Age of Reptiles," when the great Appalachian mountain chain, now reaching from New England to Ala-

bama, was but a series of low, rolling hills, there lived a long-tailed, lizard-like reptile to which scientists have given the generic name Varanops. Varanops was much like the monitor lizard (*Varianus niloptius*), now abundant in Egypt, which the natives never kill because it eats the eggs of the crocodile. While we do not yet know, as Osborn observes, the actual generalized ancestor, or ancestors, of the eighteen original and the four surviving Orders of reptiles, Varanops represents a primitive type from which all the later and highly specialized types, including the Dinosaurs, might well have been derived. Among the ancient orders of Mesozoic times were the giant sauropods, herbivorous quadrupedal Dinosaurs, to which the ancient Brontosaurus belonged—and of which the mysterious beast of the Belgian Congo may conceivably be a surviving representative.

Having traced, through Varanops and its successors, the cousinship of the Brontosaurus to the lizards and chameleons, gila monsters, snakes, turtles, crocodiles, and alligators of today, another surprising fact presents itself. The ancient Brontosaurus of Africa probably had American ancestors.

Already, in Permian times, and more especially in the Triassic period which followed, hundreds of species of highly developed reptiles were, as previously stated, abundant both in Africa and in the Americas; and it is possible that this continent may have been the home of the Permo-Triassic ancestors of the Brontosaurus-like creatures of Africa, instead of the reverse—though the Karoo formations, of Cape Colony, have gained the support of most experts as the original home of the great reptiles. But (and here is the important point) what appear to be more primitive Dinosaur fossils—a petrified footprint is a "fossil"—have been found in North America, as we have seen—notably in the ancient mud-flats of Connecticut.

Professor Lull finds in some of the Triassic footprints of New England the beginnings of an herbivorous offshoot of the primitive carnivorous Dinosaur stock, leading from bird like bipedal lizards to the broad-footed, quadrupedal type of vegetable-eating Dinosaurs known as the Sauropoda.

The earliest Dinosaurs had developed strong hind legs at the expense of the fore-limbs, and walked exclusively on these greatly enlarged hind-limbs, as is evidenced by their foot-prints. Only occasionally did they leave imprints of the small, sharp fore-claws. The newer and heavier type (sauropods), adopting a vegetable diet, and subsisting on the succulent vegetation of the lagoons, lakes, and marshes, gradually lost their sharp, typically reptile teeth, and developed strong, slow-moving elephantine legs, made necessary by their increasingly ponderous bulk.

But this does not mean that the power of raising the body on the hind-limbs, for the purpose of reaching leaves otherwise out of reach, had been wholly lost. The long, heavy tail served to balance and support them in more or less of a sitting posture, thus enabling them, at the climax of their development, to reach foliage over thirty feet above ground. And these great creatures needed abundant food to nourish

bodies of from thirty to forty tons! Even a modern five-ton circus elephant is fed 100 pounds of hay and 25 pounds of grain daily, and still reaches out its proboscis for peanuts and more peanuts. The Brontosaurus had but to lift its head to feed on esculent leaves twenty feet above it, while its huge body floated lazily in the water.

One sauropod (*Plateosaurus*) has been discovered in Germany which typifies a sort of halfway station between the older carnivorous Dinosaurs of bipedal habit and the later quadrupedal herbivorous Sauropods. Several interesting stages are still undiscovered, but may at any time be found, as there can be little doubt of their existence in rock strata somewhere.

While the early forms of the Sauropoda, or Brontosaurus-like animals, abounded in Connecticut, these unarmored and comparatively gentle saurians finally made their way to the flood-plains of a long stretch of country just east of what is now the Rocky Mountains, then still unborn. Before vertical movement and continual horizonal folding of the earth's crust had thrown up a mountain-chain, this region was a valley with a climate comparable, perhaps, to that of Central Africa today. The flood-waters were brought down from the mountains of the so-called Great Basin, to irrigate the meadows and lowlands of Wyoming and Colorado. Here, and in part of what we now call South Dakota, lived species of the largest animal yet known to man. Some of these creatures measured at least a hundred feet, ten feet longer than the largest whales.

The wonderful Brontosaurus skeleton to be seen in the American Museum of Natural History, in New York, is only 67 feet long. But some of its tail vertebrae were missing when it was assembled, the inclusion of which now would bring it to 87 feet; and there is no reason to suppose that this particular specimen was anywhere near the largest known in its locality.

For instance when, some years ago, a "thunder lizard" was found in East Africa that must have been, when alive, a hundred feet, long, Dr. Osborn gave it as his opinion that this reptile, *Gigantisaurus* (similar to the American *Brachiosaurus*, a species closely related to the *Brontosaurus*) "described as the largest land-living vertebrate . . . does not exceed in size the sauropods discovered in the Black Hills of South Dakota."

In Colorado and Wyoming dwelt also the less ponderous *Diplodocus*, a specimen of which is now on exhibition in the Carnegie Museum in Pittsburgh. This sauropod grew to a length of 80 feet or more, and rose to a height which would make the famous African elephant "Jumbo" look like a small animal. But it was less bulky and lighter on its feet than the Brontosaurus, much as a greyhound might compare with a Newfoundland dog. It may be remarked here that Lepage and Capelle claimed to have found, besides the footprints of the mighty creature they reported seeing in the subterranean lake, smaller footprints also. These might possibly be the imprints of a young Brontosaurus—assuming that the whole story is not imaginary.

Fossil Sauropods have been found not only in Africa and North America, but also in Patagonia in South America, and in Great Britain

and southern France in Europe. Interesting also is the discovery by Dr. Roy Chapman Andrews of fossil Dinosaur eggs in the Gobi Desert, Mongolia. They all became extinct, however, so far as is actually known, before the "Age of Mammals." The North American types died out even earlier, before the latter half of the Cretaceous (Age of Chalk) —at least 175,000,000 years ago.

The question is: How could the American sauropods reach Africa, if they originated in this country? Or, how could they reach Patagonia and North America, if they originated in Africa?

It must, I repeat, be clearly understood, to begin with, that no scientist believes that two groups of animals almost alike in every important particular have ever originated from different ancestors, in widely separated regions. Nature never repeats herself in this regard, so far as is known, except in *external* shape, including limbs. Different Orders of the Reptilia may have had different lines of descent from much more primitive forms; but we should assume, on sound principles, that all the bipedal Dinosaurs had a common ancestry from a single group (Amphibia), and that all of the herbivorous Sauropods had likewise a common ancestry through some one branch of the older Amphibia.

The Sauropods could have reached Africa from South America in the same way (but, as we have seen, at a different time and place) that camels which apparently originated in North America, reached Europe and Asia, or that the elephants, natives of Africa, at a much later period reached America—namely, by a land-bridge connecting the two hemispheres. Hence we should not be surprised to find fossil representatives of the Sauropods in North America, Argentina, France, Great Britain, and Africa.

It is, then, theoretically possible—though quite unlikely—that descendants of these very ancient animals still exist in some of the unexplored regions of equatorial Africa, or elsewhere. Protected by the climate and isolation of their jungle home, they may have escaped the universal fate of their herbivorous brothers and their carnivorous cousins in other portions of the world.

What was it that brought an end to all (or all other) Dinosaurs before the beginning of the Tertiary Era? As far as the sauropods (which certainly died out before the carnivorous Dinosaurs) are concerned, the wonder is that they survived so long. The bulky, semi-aquatic animals were, it is true, capable of seeking food in the meadows that bordered their homes when driven out of the water by necessity. But their lack of grinding teeth made the prairie vegetation undesirable as food; while, once on the land and unable to escape their enemies by swimming, their want of defensive armor or offensive weapons made them easy prey to "the claws that snatch, the teeth that bite" of their unfriendly relatives, the predacious dinosaurs.

Another cause tended to accelerate their extinction. Like all reptiles, Brontosaurus and Diplodocus laid eggs, just as do their near kin, the birds. Now, the beginning of the "Age of Mammals," as its name indi-

cates, saw the rise of the Mammalia to a place of dominance, a status they maintain more than ever today. These mammals, even the archetypal specimens whose fossil teeth and jaws are found in rock strata together with remains of the sauropods, were quick and relatively intelligent, even though they were scarce and weak. A forty-ton Brontosaurus rejoiced in a brain weighing just about a pound and a half—in fact, the portion of the spinal cord that moved its mighty tail was larger than all the gray matter in a head the size of that of a horse. Quickness and forethought were not among its characteristics; and the female Brontosaurus undoubtedly left her eggs right out where an inquiring mammal, no larger than a hedgehog, could investigate them. These early mammals were mostly insectivores; but few creatures that eat animal food will despise eggs. Many and many a Brontosaurus egg must have vanished by this route.

If the egg of the Brontosaurus was as large in proportion to the mother's bulk as was the egg of the recently extinct Brontornis (thunder bird), or of the Aepyornis (most lofty bird), a single specimen must have been a banquet for a host of Cretaceous mammals. (The size of the eggs found by Andrews in Mongolia suggest that this must have been so.) So far as Aepyronis is concerned, in 1851 a French traveler in Madagascar found two unbroken eggs that measured nine by thirteen inches, equivalent to about 148 hen's eggs, or six ostrich eggs—the mother-bird being about ten feet in height. Doubtless the Brontosaurus egg far exceeded this in size. Like most reptilian eggs, it probably had a tough integument instead of a shell, which would make it easy for the tiny rodent teeth to bite it through.

Another factor which must have contributed to the death of the Sauropods was the increasing cold and augmented aridity of their habitat. It is significant that this was least noticeable in equatorial Africa. Their eggs, exposed to the elements, and undoubtedly taking a long time to hatch, must very often have lost their fertility and died. A creature the size of a Brontosaurus cannot lie on an egg to keep it warm; and in any event there could have been very little heat in its reptilian body during cold weather. So countless numbers of Brontosauri must have been killed off before birth.

Add the conflicts with carnivorous dinosaurs, especially the dreadful *Tyrannosaurus rex;* and diminution of the food supply through elevation of the land with consequent increase in general aridity and lowered temperature: and the problem is, not why did the Sauropoda die, but how could any of them have survived?

Still, Africa, the Dark Continent of mystery, may yet give up from the depths of some Congo cave, or jungle lake or swamp, a "holdover" equivalent to *Sphenodon* or the crocodiles of today.

CHAPTER VII

THE ORIGIN OF BIRDS

ONE often meets with the statement that Birds evolved from Dinosaurs; which is much like saying that elephants evolved from Pachyderms, for the Dinosaurs, like the Pachyderms, do not form a natural Order. Both represent an assemblage of animals only superficially alike, owing to parallel adaptation to a similar environment. They "resemble" one another—as a reptilian group, in the one case, and as a mammalian assemblage in the second—but are not genetically related to one another. Similarity of outward form is by no means a safe criterion of relationship. In a sense, all reptiles are related, in that they had a common ancestor. At some stage in reptilian evolution, the common ancestor gave off two branches, one leading to the lizard-like types, the other to the bird-like forms. The hip or pelvic bones of the two groups, or Orders, are quite distinct in type.

In his Presidential address previously quoted, Professor Matthew names two quite distinct natural orders of ancient reptiles.

The crocodile-like group—**all with a similar type of pelvic bones**—constitutes the Order *Saurischia* (lizard-like ischium, one of the bones of the pelvis), which includes Marsh's two groups of Sauropoda and Theropoda.

The second Order is the *Ornithischia* (bird-like ischium). This stock is also known as Orthopoda (the Predentata of Marsh [1831-1899]—so named because they developed a special bone in the front part of the jaws that is devoid of teeth).

The first group, the Saurischia, with crocodile-like pelvic bones, includes the sub-order Sauropoda, gigantic quadrupedal amphibious dinosaurs (essentially herbivorous); the great carnivorous dinosaurs (suborder Theropoda, large bipedal creatures); and the suborder Coelurosauria, slender, swift-running, bipedal carnivores; also the more primitive Triassic dinosaurs.

The second group, the Ornithischia, or Orthopoda, with bird-like hip-bones, includes the cynodonts and duck-billed dinosaurs (Ornithopoda), bipedal herbivores; the Ceratopsia, horned dinosaurs (quadrupedal herbivores); and the armored dinosaurs (Stegosauria), also a quadrupedal herbivorous type.

All the Ornithischia are distinguished by a horny beak or bill and a bird-like arrangement of the pelvic bones, and have, says Professor Matthew, "a certain degree of affinity to primitive birds." It is worthy of note that the carnivorous or primitive dinosaurs have three toes as do most birds. This linkage with the birds is not nearly so significant as is

the nature of the ankle joint. In mammals and living reptiles, as Shuchert remarks, the ankle joint is between the small bones of the ankle and the two larger ones of the lower leg. "Birds and dinosaurs, on the other hand, have some of the ankle bones united with the leg bones, so that the joint comes in the middle of the ankle itself."

The legs of birds are constructed on essentially the same type as those of reptiles, differing markedly from the arrangements found in the human skeleton. "On the other hand," as stated by Shipley and MacBride (*Op. cit.*, p. 613), "they agree with the modifications of the hind limbs found in those extinct Dinosaurs which were bipedal." A bird walks on its toes, and like reptiles possesses an intertarsal ankle joint.

The raised sole of the foot really constitutes the visible "leg" of most birds, the thigh being altogether, and the shank mostly, buried in the feathers. In many birds the sole is plated by scales which are raised horny plates of skin, similar to the scales of reptiles. The fifth toe corresponding to the little toes of the human foot is always absent.

As for the egg of the bird, it is essentially like that of the reptile, both in size and in envelopes. Prof. H. H. Newman says ("Vertebrate Zoology," p. 265): "The developmental history, though much more rapid, as the result of higher temperature, is essentially reptilian. Like the reptile, the bird's jaw consists of several bones and articulates with the quadrate."

The red blood corpuscles are nucleated as in the reptile.

Huxley so clearly perceived the close affinities of birds to reptiles that he combined the two divisions under the name *Sauropsida*. Lucas says: "If we compare the skeleton of a Dinosaur with that of an ostrich —a young one is preferable—and with those of the earlier birds, we shall find that many of the barriers now existing between reptiles and birds are broken down, and that they have many points in common."

Dr. W. K. Gregory emphatically declares that "the whole architecture of a bird skeleton, indeed the whole internal anatomy, is unquestionably a modification of a primitive reptilian type." The single occipital condyle at the base of the skull is a typical reptilian feature, as are also scaly feet and hard-shelled (or tough membranous) eggs.

The heart and arteries of the bird are the same as those of the crocodile with the exception of the left systemic arch, which is not found in birds. Unlike other Reptiles, the ventricle, in the crocodile, "is almost completely divided by a septum into a right and left chamber, leaving only a small foramen between. Thus there is practically a complete separation of venous and arterial blood," as in Birds and Mammals. The crocodiles "have followed part way several of the evolutionary paths that have been carried out fully by the birds" (Newman).

Dr. David Meredith Seares Watson, Jodell Professor of Zoology, London University, has, in "Creation by Evolution" (chapter on "The Evolution of the Bird," pp. 242-254, edited by Frances Mason, 1928),

strikingly brought forward some very interesting points in avian evolution. He points out, for example, that

In order to enable the bird ancestor to utilize fully the increased activity made possible by its higher body temperature, many changes of its structure were necessary. One of the most important of these has to do with the heart. A lizard can run very fast for a short distance, but it then collapses, completely exhausted, whereas a mammal or a bird can hardly work so fast and so long that its muscles will no longer contract. This difference is due to the fact that the mechanism for sending a supply of oxygen to the muscles is much better in the bird or mammal than in the lizard.

The heart of a bird consists of two pumps, placed side by side. Into one of these pumps, that on the left side, blood full of oxygen comes from the lungs. This blood is then pumped forward, through a great tube, which turns over to the right side of the animal and gives off blood vessels to all the muscles and all parts of the body except the lungs. All this blood, after being deprived of its oxygen, goes back to the right side of the heart and is then sent to the lungs to get a new supply of oxygen.

As for brain development in birds, in comparison with reptiles, Professor deBeer finds in the avian brain an elaboration of the grade of structure shown by the brain of crocodiles, "and its distinctive feature is that the *corpus striatum* has been especially developed while the cerebral cortex remains small and thin."

He points out that the cerebellum of birds presents many resemblances to that of the Pterosaurs, which, however, he adds, "can be explained as due to the action of similar modes of life working on related materials."

Professor Watson points out that the brain of the bird is bent sharply on itself, so that the optic lobes of the mid-brain—portions connected largely with vision—are pressed downward and the hemispheres are brought clear to the cerebellum, which, in contradiction to what is the case in most reptiles, is large and transversely wrinkled. Evidence is accumulating that an important function of the cerebellum is to coordinate the motor impulses to the skeletal muscles which bring about the correct balance of the animal. As balance is a more difficult matter in a bipedal animal than in a quadruped, the cerebellum of birds is correspondingly enlarged.

A strong light is thrown on the development of the bird's organs of thought, which are high and rounded, by Professor Watson. Sections, he says, reveal the fact that

The great mass of the hemisphere is composed of an enlargement of the corpus striatum in the mammalian brain. The roof of the hemisphere corresponding to the cortex in Mammalia is thin. Now in mammals the corpus striatum is generally regarded as the seat of those impulses which carry out the instinctive activities, whereas the cortex is the seat of purposive action. In accordance with their brain-structure, we find that birds are creatures of instinctive impulse, and have not nearly so much intelligence as they are usually credited with by imaginative people.

However, they have more than they are credited with by zoologists who have made no special study of their behavior under varying con-

ditions. Dr. Watson's example of the stupidity of cuckoos is not entirely conclusive.

Professor deBeer remarks upon the fact that the peculiar lung of the birds is primitively represented by the air-sacs of the lung of the chameleon. In the flying-lizards (Pterosaurs) of the latter half of the Mesozoic Era, there were hollow, air-filled bones, as in birds. In the humerus (upper arm) of both Pterosaurs and birds there is a foramen (a small opening) for communication between the lungs and the cavity of the bone. But, as Lull points out, birds acquired a remarkable development of air-sacs, principally in the abdomen, but in other portions of the body as well, and these adaptations are not met with in Pterosaurs.

The Pterosaurs (Pterodactyls) were already a highly specialized branch of the Reptilia when first met with in the geological record (Jurassic time), so they cannot be ancestral to birds.

CHAPTER VIII

THE ORIGIN OF FEATHERS

THE distinctive badge and livery of the Order of Birds, said the lamented Dr. Frederic A. Lucas, in a popular article written for the New York monthly, *Evolution* (July, 1929), a few weeks before his death, is that they wear feathers.

No bird is without them, no other creatures wear them, so the bird may be exactly defined in just two words, *feathered animals.* The exclusive mark of birds is therefore not flight but feathers, though in penguins, the feathers have so changed that their identity is almost lost.

(Probably a number of readers will remember having seen in a sideshow the "hen with hair." It did seem to be covered with hair, but I have no doubt that the microscope would have revealed only highly modified—perhaps diseased—feathers.)

It has, I believe, been clearly shown that birds are very closely related to reptiles, and are really only highly modified reptiles dressed up in feathers. But we must admit that no reptile is clothed with feathers. And as it is a principle of evolutionary theory that we never get something from nothing; that all the structures in both plant and animal life that we see today are but modifications of pre-existing structures—either as progressive or as degenerate (or at least regressive organs)—it becomes incumbent upon the evolutionist to trace the initiation and progress, if it be a progressive adaptation, of any new feature.

If we consult the most authoritative text-books, we shall have no difficulty in solving the very interesting problem of the origin of feathers. For instance, Newman (*Op. cit.*, p. 266) says: "A feather is a modified scale, that arises from a papilla and is at first covered with an epidermal sheath." Further, a typical feather "consists of a stiff rod or stem, of which the basal portion is hollow and forms the quill or *calamus;* the distal part is filled with pith and is called the *rachis.*" But my reader is not looking for a description at this point; he wants to know where or how, or from what feathers originated. So let us turn to Shipley and MacBride (*Op. cit.*, p. 607), where we find an answer:

Strange as the statement may appear, it is true, nevertheless, that the feathers are really scales like those found in lizards, but immensely developed and with the edges frayed out. Like scales, they are epidermal, that is, developments of the outer or horny layer of skin. The area which is often to form the feather becomes raised into a little finger-shaped knob of dermis, but the upper part, like the scale of a lizard, is formed only on one side of the knob, and as this part is pushed away by the growth of the deeper parts it becomes frayed out so as to form the *vane* of the feather. . . . Down consists of small feathers growing between the bases of the larger ones. . . . . the color of the feathers is partly due to colored substances or pigments in

the epidermal cells and partly to minute detail (minute mirrors) which causes interference of the light waves reflected from them.

Yet, says Professor Watson (*Op. cit.*, p. 244):

When we compare a wing or a tail feather of a bird with a scale is seems at first impossible that one should have come from the other; but the first feathers of the chick—those which it grows while it is still in the egg—consist of very short scale-like quills, whose ends fray out into plumes. These feathers are formed from the upper layers of the skin in exactly the same way as the scales of lizards are formed; indeed, they differ from such scales only in being larger. Between these incipient feathers and those which we know as quills we find all intermediate stages.

Feathers, like the scales of reptiles, are arranged in tracts, called *pterylae,* with naked spaces between, called *apteria.* In some cases, the apteria are covered more or less with the down feathers to which I have referred.

Now, this is all very well from the standpoint of the comparative anatomist or the zoologist, armed with their powerful microscopes; but what has the rock record to contribute on this subject?

Unfortunately, but quite understandably, fossil birds are comparatively rare throughout geological history. What we know of Mesozoic land life is chiefly limited to the fauna of the swamps, and no swamp birds are known previous to the Tertiary Period. However, the oldest known feathered creature, *Archaeopteryx* (Greek, *archaios,* old, and *pterux,* a wing), found in the Jurassic slate quarries of Solenhofen, Bavaria, is so closely allied to the Reptilia in structure that it is doubtful if it would have been recognized as a bird by its skeleton alone; but the associated feathers offered conclusive evidence of its place among the Aves.

The first intimation of bird life in the Mesozoic era was the imprint of a single feather in the Solenhofen lithographic stone, found on August 15, 1861. Less than a month later the fossil skeleton itself was discovered, followed in 1877 by a second and better preserved specimen. all from the same quarries. The birds found were of different species, or even of different genera. Since that time no Juarassic bird relics have been found.

Archaeopteryx was a small bird, hardly as large as a pigeon, with a small, stout, entirely bird-like head excepting that its jaws ("bill") were equipped with numerous small, sharp, conical teeth, instead of being of horn, as in modern birds. The brain was bird-like, but relatively small, as in later Mesozoic birds. The fingers of the "hand" had not yet coalesced, by reduction, there being four separate fingers, or reptile-like claws, all of them functional. The fingers retained the same number of joints as the corresponding fingers of a lizard. Thus the bird was enabled to crawl about the trees by aid of its claws, much in the manner of the young Hoactzins of South America (abundant in British Guiana).

Probably the first stage from a terrestrial to a terrestrio-arboreal mode of life consisted of climbing up the tree by means of the claws and parachuting down again by means of partly developed wings, or

feathers, on both arms and legs, the leg feathers degenerating after full development of the wings in the course of time. William Beebe has observed great feathers on the thighs of modern birds when in the embryonic stage, and attributes traces of similar feathers to the thighs of *Archaeopteryx*. From these observations he infers that the original method of bird flight was four-winged, the long tail of *Archaeopteryx*, with its 21 vertebrae each provided with a pair of tail feathers, acting as a rudder.

That the Jurassic bird had not developed full powers of flight is shown by the feebly developed breastbone. (The reader might consult with advantage Lucas's "The Beginnings of Flight," *American Museum Journal*, Vol. 16, 1916; and, by the same authority, "Animals of the Past," American Museum of Natural History, Handbook Series, No. 4, 1922.)

In the later birds, as also in the flying-lizards and the flying-mammals (bats), the breastbone (keel) is strongly developed. In all three flying groups, bats, birds, and pterodactyls, a vertical keel grows upon the breastbone, in order to furnish a sufficient bony attachment to the powerful and greatly developed breast muscles, which are the principal muscles of flight.

Recalling the "Biogenetic Law," it is interesting to note that tooth-germs always appear in the embryos of certain birds; and in all embryonic birds the wing ends in a sort of paw and the fingers are separate. In ostriches the wing retains reptile-like features even in adult life.

In many groups of birds the first digit has a claw, as, for example, the spur on a swan's wing, and several birds have claws on both the first and second digits.

Embryonic teeth, as said, are discernible in a few, but only a few, birds, and then only as mere rudiments. But not one of the more than 15,000 kinds of birds now living possess adult teeth.

Archaeopteryx was not a product of "special creation," or if it was, the "handiwork" was decidedly bungling; as bungling as that performed on Man, whom Schopenhauer called "a burlesque of what he should be." Just so, we may well admire the early struggles of *Archaeopteryx*, when we compare its structure with that of a modern bird. Dr. Watson says:

> It is certain that *Archaeopteryx* was clumsy, incapable of hovering over one spot and of alighting on a definite perch. . . . It was ill constructed, and lacked that perfection of form and motion which makes the sea gull a constant source of delight. Is it credible that a bird that was miraculously created in a moment should be so imperfect? Is not the imperfection of the machinery an evidence of evolution? Is it not more reasonable to recognize in *Archaeopteryx* a necessary stage in the long process by which a crawling reptile was gradually converted into a flying bird of today?

The next known stage in the evolution of bird life is represented by fossils found by Professor Marsh (1870-77) in the Upper Cretaceous limestone formations of western Kansas. Great was the surprise of American zoologists when, in February, 1873, he announced the presence

of teeth in the birds of the ancient epicontinental seas of western America. Both birds found were aquatic in habits, one, *Hesperornis,* being a large wingless diver, nearly six feet in length, and loon-like in structure; the other, *Ichthyornis* (Greek, *ichthus* fish, and *ornis,* a bird [the "*hesper*" in the name of *Hesperornis* means "western"]), a small bird of tern-like aspect, not so large as a crow. Unlike *Hesperornis,* the small bird had great powers of flight. The jaws of both birds were supplied with small teeth. In *Hesperornis* the teeth were imbedded in grooves, firmly fused to the bone, as in many reptiles; while in *Ichthyornis* the teeth were set in definite alveoli (cup-shaped sockets), another arrangement sometimes found in the jaws of reptiles. In the Cretaceous birds the long, vertebrated tail of *Archaeopteryx* had given place to one intermediate between the latter and modern birds. As in the Jurassic birds, the vertebrae were biconcave, as in fish and some reptiles.

CHAPTER IX

THE ORIGIN OF HAIR

JUST as feathers are characteristic (or diagnostic) of birds, so hair is characteristic of mammals, which, typically, display it as a complete covering of the body. The class Mammalia (Latin, *mammae,* breasts) includes those animals which suckle their young. But there are no land animals which suckle their young which are not covered by hair either before birth (as in the case of elephants) or after their prenatal life, excepting a few which have developed quills (e. g., spiny ant-eater, porcupine) or overlapping scales (e. g., armadillo), which are really formed of aggregated hairs.

A hair is essentially a rod composed of closely packed cells converted into horn (in the case of a rhinoceros a very practical "horn"), such cells being well seen under a good microscope as a mosaic on the surface of the hair. The outermost cells overlap each other like shingles on a roof, and, as a matter of fact, serve the same function, "letting the water run off." (The outside of the feather also, as we have seen, is composed of horny cells. The horns of deer, etc., consist of a sheath of epidermal substances supported by a bony core.)

It is not necessary, in this book, to go into detail concerning the growth or the "anatomy" (really histology) of hair. The continual growth of the hair, it may, however, be added, is made possible by a little plug of dermis carrying blood-vessels, which is pushed up into the lower end of the hair. This plug of dermis is called the *papilla* (of the hair), and corresponds to the knob of dermis in the base of the feather; hence a hair might be compared to a feather consisting only of the shaft, and sunk in a very deep and narrow pit of the skin, formed by a thickening of the deeper layer of the epidermis, which grows down into the dermis forming a little cylinder, at the base of which the papilla is formed.

CHAPTER X

PRIMITIVE MAMMALS

WE have already met with the phrase, "egg-laying mammals." There are but two families of this lowly subclass (*Prototheria*) of the Mammalia; namely, the Ornithorhynchidae, and the Echidnidae, constituting the Order *Monotremata*. The contemporary representatives of this subclass consist of but three genera, native to Australasia. These egg-laying mammals, bird-like in some features, and also containing in their structure some reptilian characters, exist nowhere else but in Australasia.

The African suborder Theriodontia (beastlike teeth), with mammal-like heads, are regarded by most authorities as having given rise to the lowest of egg-laying mammals, "while in the American forms originated the higher reptiles" (Schuchert).

About the time of the rise of the monotremes and marsupials (egg-laying and pouched mammals), the southern hemisphere was united into one great continent, and then disconnected. Only in this way can we account for the distribution of fossil and living forms of southern florae and faunae. That is to say, so far as our present topic is concerned, we may thus (and in no other way) account for the presence in Australia of very primitive forms of mammals which were once widespread over the earth, but are now, as said, found nowhere else.

The body of the Monotremes is constructed largely on the plan of that of birds and reptiles, there being but one opening for the products of the urinary, digestive, and sex organs.

While the modern Monotremes reveal to us a most remarkable stage in the evolution of reptiles to mammals, connecting with the higher Marsupialia (Metatheria) on the one hand and with the egg-laying Reptilia on the other, they must be regarded as highly specialized forms, and therefore not *direct* links in the chain of mammalian development. We may assume, however, that their Mesozoic ancestors were generalized transitional forms. If so, they must have been possessed of tuberculate teeth, *i. e.*, teeth with small, rough prominences. And this is precisely what a study of the embryonic life of the Monotremata actually shows, for the calcified teeth found in the embryo of the *Ornithorhynchus* strongly resemble the teeth of the *Allotheria*, or *Multituberculata*, a family of primitive mammals whose fossil jaws have been found in North and South America and in Europe and Africa. No teeth of any other living or extinct animal correspond to the form of the embryonic teeth of the "duckbill" with the exception of the multituberculate dentition of the *Allotheria* of the Mesozoic Period. Perhaps such primitive mammals as the *Micolestres* of the Lower Triassic of Europe, and the

Dromatherium sylvestre of the same geologic age in North Carolina, afford examples of just such generalized types as would be needed to unite the reptilian and mammalian classes. Lull says: "The teeth of some of the earliest mammals differed little from those of Theriodont reptiles, in which the tuberculation of the molars characteristic of mammals had already commenced. . . . [In certain instances,] these teeth are quite suggestive in general type of those of the rat-kangaroos of Australia and Tasmania."

In general, the mammals of Mesozoic times were very small. Usually they were about the stature of a rat. *Meniscoessus* of Basal Eocene is as large as a beaver. Larger forms would have had but little protection against the predacious habits of the saurians, unless of strictly arboreal type. Smaller forms could escape by burrowing.

It is significant that many of the early mammals in the "Age of Reptiles" were insectivores or of arboreal habits. Possibly the mammals of the Jurassic and Cretaceous Periods, as Prof. Edward D. Cope (1840-1897) suggests, did much (as remarked previously) to annihilate the great saurians of the Mesozoic by destroying their eggs with their sharp incisors. "The insectivores among placentals, and opossums among marsupials, are the only animals which have preserved the dental prototype close to that of the pro-mammal," says Professor Osborn. The teeth of *Cimolomys gracilis* and *Halodon sculptus* are important links in the chain connecting the Mesozoic and Tertiary mammals. The discoveries of Marsh in the Laramie deposits of Wyoming, and the primitive mammalian remains uncovered by Lemoine at Cernay, France, have helped materially in bridging the chasm that separated the Jurassic forms from the Mammalia of the lowest Tertiary (Puerco-beds).

The *Pantotheria* (*Tuberculata*) are considered by Professor Lull and other high authorities as having been "the actual forerunners of the insectivores. . . . To this order belong *Dryolestes* and *Diplicynodon* from the Comanchian [Cretaceous] of Como Bluff, Wyoming, and *Didelphodon, Cimolestes,* and others from the Upper Cretaceous Lance formation of the same state."

The Prototheria (first or lowest mammals) **of the Triassic Period,** the lowest stage of the Mesozoic Era, separated very early into two branches of *Metatheria* (transition mammals), the one more like the Marsupials, the other more like the Insectivora. From the latter were derived the *Eutheria* (perfect or true mammals), which later deployed and differentiated into many specialized orders. There are now known more than 60 genera of Mesozoic mammals, and the number of species is, of course, much greater.

Following the Monotremes in the scale of evolution are the Marsupials, or pouched animals (Kangaroo, wombat, opossum, etc.). With the exception of the opossum, and the rat-like *Coenolestes,* the Marsupials are found now only in Australasia. They represent the highest point of development that had been reached in the Antipodes when Australia was cut off from the rest of the world; namely, from New Zealand in Triassic times, and from the great northern continent (Gond-

wanaland) during the Upper Jurassic or the early Cretaceous. A broad land connection between North and South America permitted the migration of the Mesozoic forms northward on this continent. Here the high development of predaceous saurians, and later of the carnivorous mammals, led to the extinction of the Monotremes, and left comparatively few Marsupials. Twenty-three species of opossums, *Didelphia, Chironectaae,* and the *Caenolectes* of Ecuador and Colombia, are all that remain in South America of these very interesting relics of Gondwanaland, while in North America but two or three species remain to show us what the possible ancestor of the higher mammals was like. It is not supposed, however, that our surviving opossums are exactly like the ancient stem-forms of Australia; but they carry us very close to their nearer relatives of the Upper Mesozoic rocks.

Australasia is, in a sense, a Museum of Living Fossil Forms, revealing to modern scientists important transitional types in the progress from amphibian like reptiles (*Sphenodon*) to reptile-like mammals (Monotremes), on to arboreal Marsupials, which connect, perhaps, with the early arboreal Insectivores, ancestral to the Apes and Man. In the Monotremes we see sweat-glands transformed into lacteal organs; and the ear-hole begins to be covered with a shell of cartilage, the beginning of the Mammalian external ear. More difficult is it to trace in detail the origin of the hair, which so well serves the aquatic Duckbill (*Ornithorhynchus*) for the retainment of bodily warmth. Hairs, as we have seen are not modifications of reptilian scales, as are feathers. The recurrent arrangement of the hairs, however, due to their original development behind scales, has very generally persisted, and may be considered to imply the earlier presence of scales.

The Monotremata, though classed as mammals, have no true breasts, as have all the placental mammals. In the case of the Duckbill (Platypus), the mother's milk is forcibly drawn through tiny holes in the skin of what does service for a breast (Henry Burrill, "The Platypus"). The mother lays her eggs in a nest, underground, the number being one to three—usually two. They measure about three-quarters of an inch in length and two-thirds of an inch in diameter. When first laid, they are covered with a sticky coating, like fish glue. As they lie side by side, they stick together, and are kept sufficiently warm by the mother, who coils her tail around them, holding them against her stomach. The body temperature of the Monotremes is intermediate between the cold-blooded reptiles and the warm-blooded placental mammals; and as in the case of reptiles, the body changes its temperature according to the changes in the temperature of the surrounding conditions, a variation of at least 15° Centigrade.

The Family *Ornithorhyncidae* consists of but one species, *Ornithorhychus anatinus*—the Duckbill Platypus or "duck-billed mole." (Ornithorhynchus is Greek for "bird bill.") Its brain is the most primitive of any known mammal. The cerebral hemispheres are, as in the reptile brain, entirely lacking in convolutions.

The Family *Echidnidae* contains two genera, *Echidna* and *Proechidna*. *Echidna aculeata* is popularly known as the "Australian ant-eater."

It is found in Australia, Tasmania, and New Guinea. It has a covering of quill-like spines, with an underlying covering of coarse hair. The Platypus, on the contrary, has a heavy coat of soft brown fur, the feet being web-toed (five toes).

The transition from Theromorph reptiles to mammals must have taken place in the Permian, as indicated by the researches of Broom, Watson, Houghton, VanHoefen, and other eminent experts. At any rate, early in the Triassic, fossils are met with which show a distinct advance toward true, though as yet lowly, mammalian forms. In his paper of 1914, on "The Structure and Affinities of the *Multituberculata*," (Bulletin of the American Museum, Vol. 33), Broom seems definitely to have shown that these fossil forms belong to the Prototheria (Monotremata, egg-laying mammals), and not to the Marsupials, as we formerly thought probable. He regards the living Australian Monotremes as specialized and degenerate descendants of the Jurassic Multituberculates. Some of these forms persisted until the Eocene period, and advanced in general evolution to the Marsupial stage. Professor deBeer says of them (*Op. cit.*, p. 453):

> The pelvis was narrow as in the reptiles, and the lower jaw, which contained a single bone, had inflected angles (a marsupial trait). The single bone (dentary) in the lower jaw is a characteristic mammalian feature. The *Multituberculata* were, however, specialized, and possessed molar teeth with a large number of cusps (hence the name). They are probably a divergent line which evolved parallel with but independently from the remaining mammals.

J. T. Carter contributed important papers on the microscopic structure of the teeth ("Structure of Enamel in Marsupials," *Philosophical Transaction of the Royal Society*, Series B, Vol. 208, 1917, and *Journal of Anatomy*, 1919; "Structure of Enamel in Primates." *Proceedings of the Zoological Society*, 1922), in which he demonstrated that the enamel pattern, in conjunction with tube penetration of the enamel, makes it possible to discriminate clearly between multituberculates, Marsupials and Placentals, and the different groups of Placentals. Carter's later researches led him to the conclusion that enamel pattern is more important than tubular penetration in determining affinities.

The earliest fossil jaw found in North America which has been positively identified as a marsupial was discovered underneath a dinosaur jaw of the Cretaceous period in Montana, by Barnum Brown, of the American Museum of Natural History. It proved to be a near relative or ancestor of the existing opossum, which is therefore one of the most ancient types of "living fossils" among extant mammals.

Genuine placental mammals are now known to have existed in Mongolia as early as the Cretaceous, thanks to the labors of the American Museum of Natural History party in the Gobi Desert, under the leadership of Roy Chapman Andrews. The good fortune of finding the world's oldest fossil of a placental mammal fell to the lot of the keen-eyed Walter Granger, one of Andrews' most competent co-workers.

In an article on "Missing Links of the Gobi Desert" (*Scientific American*, April, 1927), Dr. William K. Gregory, the Museum's curator

in the Department of Comparative Anatomy, and professor of vertebrate Paleontology in Columbia University, tells us that:

The Mongolian placental mammals had reached a very critical stage in evolution in which the upper molar teeth had a low cusp on the inner side of the shearing blades and each lower molar consisted first of a triangular wedge, fitting into the interspaces between upper molars, and secondly, of a spur or heel on the hinder border of the tooth which engaged with the internal cusp of the upper teeth. This is the sort of tooth which, so students of the evolution of mammalian molar teeth had predicted, ought to be found in the Cretaceous ancestors of the placental mammals. And now the Mongolian Cretaceous placentals are found to have exactly that kind of molar teeth.

Popular stories and moving pictures and cartoons commonly represent man as a contemporary of the dinosaurs; but the cumulative evidence of thousands of fossils from successive ages establishes the high probability that man did not appear as such until millions of years after the last dinosaurs had vanished from the earth. In fact, all well-founded paleontological and anatomical research leads to the inference that at the time of the Mongolian Cretaceous mammals the Primates, that great order of mammals to which man belongs, had at most barely assumed the stage represented by the existing tree shrews, and would not for several millions of years produce relatively high beings, such as monkeys and apes, not to mention mankind, who by the most liberal allowance can scarcely claim to be older than the Oligocene, a far later period than the Cretaceous. But it is even reasonably safe to regard certain of the Mongolian Cretaceous mammals as representing in a general way the appearance of our own remote ancestors in the days of the dinosaurs.

Huxley, with his usual prescience, long ago predicted that some day fossil remains of the ancestral placental mammals would be discovered, and that when found they would resemble modern insectivores in respect to the general form of the teeth and lowly development of the brain. Dr. Gregory reminds us that::

Henry Fairfield Osborn and other paleontologists also taught that the ancestral placentals were insectivorous mammals which were at the same time the source of the creodonts or early flesh-eaters, of the hoofed animals, and of the primates (lemurs, monkeys, apes, man). This great generalization has received strong support from the Mongolian Cretaceous mammal skulls.

There are primitive, generalized insectivores living today which are not far from the prototype form for all higher placental mammals. Two members of the Shrew family fit well into this pattern; namely *Gymnura rafflesii*, and *Tupaia*, the Tree Shrew.

XI

THE PRIMATES

DURING the course of his revisions of his great work, *Systema Naturae,* twelve editions of which appeared between 1735 and 1766, the famous Swedish naturalist Linné (or Linnaeus) felt constrained to include man as a member of his order of Primates (which he did in 1758). As thus revised, the group included bats, lemurs, monkeys, apes, and man. Drop the bats, and substitute marmosets, and the group stands today as it did in the last half of the eighteenth century.

We have seen that while the Mammalia arose during the long Mesozoic Era—enduring for a period equal to about twelve percent of all geologic time—no member of the Primate group was numbered among the fossils so far discovered. The mammalian fossils recently discovered in a Lower Cretaceous formation in the Gobi Desert, by Dr. Roy Chapman Andrews and his colleagues, represent several kinds of animals; but none of them anywhere nearly approaches the status of even the lowliest of lemurs. For the first forms in the direct line of Primate evolution we must leave the "Age of Reptiles" behind us, and enter the Era named by Cuvier and Brogniart the Tertiary, and later very aptly called the "Age of Mammals," which in this long period of time—approximately 50,000,000 years—became the dominant animals of the earth.

In his exhaustive study of the skulls of the Cretaceous period, Deshayes noted that the strata of this system carried no species of the present living world. With the beginning of the lowest formation above the Cretaceous, a small percentage of certain fossils (Mollusca) appear which have descendants among those still existing. The percentage rapidly rises as the younger strata are laid down, rising from one to five percent in the earliest of the Tertiary formations, to nearly 100 percent in the Pleistocene.

Charles Lyell took this evolution among the shells as a basis for dividing the Cenozoic Era (comprising both the Tertiary and the Quaternary) into five epochs, or periods, the youngest being given the name *Pleistocene* (most recent); the next lower, *Pliocene* (from the Greek words meaning "more recent"); then *Miocene* (less recent); then *Oligocene* (a present-day name for the Upper Eocene, meaning "lack of recency"); and, at the base, *Eocene* (dawn of the recent), the system overlying the Cretaceous. More lately, a new epoch has been added, the *Palaeocene,* underlying the Lower Eocene beds.

The geological—or paleontological—history of the Primates begins, so far as it is now known, with the Eocene. Here we meet for the first

time with the relatives, possibly ancestors, of the lemurs and tarsioids, in Western North America—also in the Eocene of Europe.

In the Lower Oligocene (of Egypt) we meet for the first time with specimens of the larger apes, consisting of two lower jaws, one, *Parapithecus,* combining the characters of the tarsioids and the anthropoids; the other representing a form which has been interpreted as a primitive pro-anthropoid, *Propliopithecus,* ancestral, apparently, to the gibbons, and by some authorities thought to be the branch leading to the higher apes and man.

By early Miocene times true tree-living gibbons had found their way into Europe and continued throughout the Pliocene in the forms known as *Pliopithecus* and *Pliohylobates,* the latter ranging northward into the present region of Germany (see Osborn, "Men of the Old Stone Age," p. 45). Broken jaws of nearly a dozen species or genera of anthropoid apes have been found in the Miocene and Pliocene beds of India, one type of which, *Dryopithecus,* found its way to southern France. The grinding-teeth suggest those of the orang, but the jaw is not unlike that of the Piltdown man. It appears to be rather closely related not only to modern anthropoids but also to man himself. An anthropoid ape known as *Neopithecus* occurs in the Lower Pliocene of Germany, near Eppelsheim. Unfortunately, this ape is known only from a single molar tooth, which, says Osborn, "recalls the dentition of *Dryopithecus* and more remotely that of *Homo.*"

An anthropoid known as *Palaeopithecus,* found in a Pleiocene formation of the Siwalik Hills of Asia, is of particular interest in that it is a generalized form combining certain features of the chimpanzee, the gorilla, and the gibbon. The upper premolars resemble those of man. Professor Osborn believes that all these fossil apes are divergent branches of the main anthropoid stem which culminated in man, hence not *ancestral* to *Genus homo.*

It remains to call special attention to the most human-like ape so far discovered, namely, the Taungs "child" ape, studied and reported, in 1925, by Professor Dart, and given the name *Australopithecus* (southern ape). The skull was found fossilized in a limestone cave at Taungs, near the western border of the Transvaal. Dr. Broom gives it as his opinion that its age is either Pliocene or Pleistocene, "but if Pleistocene, pretty certainly early Pleistocene." It is in all probability a new species, if not a new genus. Sollas is convinced, after a careful study of the skull, that *Australopithecus* "makes a nearer approach to the Hominidae than any existing anthropoid ape."

Is man really cousin to the ape? In the next volume of this series an attempt will be made to answer this question frankly, in the light of all available evidence.

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KEY TO EVOLUTION NO. 6
Edited by E. Haldeman-Julius

Man, Cousin to the Apes

Proof of Man's Simian Descent

Maynard Shipley

HALDEMAN-JULIUS PUBLICATIONS
Girard, Kansas

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MAN, COUSIN TO THE APES

INTRODUCTION

A few evenings ago, a friend "dropped in" on me for a short visit. He is a writer by profession, and in our suburban literary colony we don't visit each other very often, and when we do, our calls are usually "brief and to the point." For most of us, time is our only capital—time, and the study behind us.

"What are you doing now?" he asked.

"Principally, I'm writing a 'Key to Evolution' for Haldeman-Julius."

"Haven't we had enough books on evolution, especially since the Scopes trial?"

"Well, yes and no. The trouble is that the books written have to be, first of all, such as will appeal to the general public—persons who have not already 'read up' on the subject. Only the most interesting 'popular' aspects of the question can be treated, if one has sizable royalties in view."

"Well, what about Haldeman-Julius? He isn't in business for his health, is he?"

"No, I don't suppose he is. Neither am I writing 'for my health.' But this doesn't mean that he, as a business man, is totally lacking in what the pretentious call 'idealism.' He has his ideal about 'the University in Print,' and I have my ideals about science. Together we are turning out what I hope is a real university course in evolution. Naturally, we believe there are enough 'advanced students' among the general public who really desire to go into the subject more in detail, and who wish to know just *how* the evolutionists have arrived at their conclusions, which are set forth, as results, so entertainingly by the popular writers."

"Perhaps you're right. I'm rather fed up on the 'evolution of the horse,' for example, myself. Moreover, those fellows make many statements which, I suppose, we laymen are expected to take for granted on their say-so. Why don't they give their authorities?"

"Citation of authorities and literature burdens their story, as a story, and they assume that the public is not interested in going ahead seriously with the study of evolution. But you must admit that many of the popularizers add a short bibliography to each chapter, or at the end of the volume."

"Yes, true enough; but how do we know which one said what?"

"It is exactly this need that I am trying to fill. I believe there is a real call for a work on evolution that will meet this objection made by a relatively few serious students. Hence the 'Key to Evolution.' But it is definitely offered as part of the very comprehensive course, or courses, of the 'University in Print.' There are already many elementary Little Blue Books dealing with the more popular phases of evolution; so I am appealing here to those readers who desire to go more deeply into the subject, and who wish to get into closer touch with the original sources."

"You mean that some readers want properly documented material. Maybe they do. At any rate, it's a fine experiment, and Haldeman-Julius deserves great credit for his willingness to try it out. I shan't keep you longer from your work. Good night!"

CHAPTER I

MEN AND MONKEYS: IS MAN A "GROUND APE"?

ONE of the most exasperating statements met with since the beginning of the Fundamentalist war on modern biological science is the oft-repeated declaration on the part of certain "reconcilers" that, to cite a recent instance (*Popular Science Monthly*, September, 1929), "neither Darwin, the father [?] of the theory of evolution, nor any other scientist, has ever contended that man is descended from the monkeys. Science has suggested, and research has tended to substantiate, their common ancestry, probably in a small tree-dwelling animal resembling the lemur."

But are not "the monkeys" descendants of some lemur-like form, and therefore higher in the animal scale than lemurs? If this be granted, and it must be, is it less repulsive to vain man to be derived from a form still lower in the evolutionary scale than "the monkeys"? Lemurs are "half-apes." Is it more satisfactory to think of having been derived from a half-monkey than from a whole monkey?

What, indeed, is meant by a "monkey"? The author just quoted admits that man and the monkeys had as a common ancestor "a small tree-dwelling animal resembling the lemur"—popularly known as half-ape, or half-monkey. Are we to understand that the branch of lemurs which evolved eventually into the human stock passed through no "monkey" or ape stage of development? It would be interesting to have some scientist explain to us what kind of animal the evolving lemur was after ceasing to be a lemur, in its upward course of evolution

"Neither Darwin . . . nor any other scientist, has ever contended" that the lemur passed directly from the lowest of the Primates to the status of a human being. At one stage of his evolution from "a lower form of life," man must have been a monkey, or ape.

From the standpoint of evolution, the stage succeeding the lemurs was *a monkey stage*—and could not possibly be anything else, as every zoologist in the world well knows, whatever his evasive assurance to the general public may happen to be. It is, therefore, incorrect to assert that "man had no monkey ancestor." Quite obviously, he had to pass through the monkey stage in order to evolve into the next higher stage—namely, the anthropoid (man-like) ape stage. More immediately, of course, he is a descendant of an anthropoid stock, not a *direct* descendant of any monkey ancestor. And the common ancestor of man and of the four still living anthropoids (gibbon, orang, chimpanzee, and gorilla) *was a generalized anthropoid ape*. It was not until this stage was reached that the five branches of apes (future man being unquestionably one of these five offshoots from the common ape stem form) began

their separate adaptations and specializations, which so conspicuously differentiate the five branches today.

At first, the five types of apes were scarcely distinguishable from one another. Millions of years were to pass before man and the four great apes assumed anything like their present aspects and characteristics. And the immediate primitive ancestral parent of all of them had for *his* ancestor a monkey. This monkey, ancestor of the higher apes, was, in turn, a descendant of a lemur-like form, the latter derived from some generalized mammal, probably an insectivore, of the Cretaceous epoch, the period which brought to a close the Age of Reptiles (Mesozoic) and introduced the Age of Mammals (Tertiary). No zoologist of standing in the world today denies these firmly established results of modern research—not, at least, if you pin him down to what he *knows* to be the facts in the case.

Yet, turning to page 27 of the most recent (1929) popular book on evolution ("Origin through Evolution," by Dr. Nathan Fasten, professor of zoology in the Oregon State Agricultural College), we read:

A sixth misconception often found to exist among unintelligent [!] laymen is that evolutionists degrade [?] man by holding that he is descended from the monkey. So universal is this belief that in many minds evolution is synonymous with "monkey descent." The fact is, however, that no evolutionist teaches this, and for the simple reason that the facts do not warrant such a conclusion.

Having delivered this sop to the "unintelligent layman" who wishes to think of himself as made in the image of his God, the professor then goes on—*to show that man is a descendant of the monkey!* On the very next page Dr. Fasten states, in substance, precisely what I have just asserted as to man's "monkey descent"!

No scientist denies that there is a very close *kinship* between apes and human beings, and that they have many common traits; but persons who have studied the problem agree that these groups are *now* quite divergent and separate, with numerous distinct variations [or adaptations] which mark them off from one another. However, it must be pointed out that careful research on the fossil human and *ape-like* remains unearthed during the last hundred years in various parts of the world has led the evolutionist to the conviction that the higher apes and human beings which exist at present . . . *originated* from some remote, pre-existing stock of mammals which possessed in common many of the distinctive characters of both [i.e., a generalized insectivore, from which the lemurs evolved]. From *this common ancestry*, in due course of time, a *monkey branch sprang*, and through adaptation and specialization this [monkey] branch has given origin to the existing types of higher apes. *Likewise*, the human stock *arose as another distinct offshoot* in a [somewhat] different direction, and from it [the stock from an original "monkey branch"] have evolved the different human races which have successively populated the earth [italics mine].

The reader will probably, and quite naturally, find it difficult to see wherein Fasten's conception of man's "monkey descent" differs from the "unintelligent laymen's"! And if he turns to page 351 of the same book he will find it still more difficult. Here our authority speaks of the "identities of organization" of the chimpanzee, gorilla, and man, though there are some striking differences, or "modifications," in the length of forelimbs and legs.

This feature, undoubtedly, is an adaptation to the typical habitats of the organisms in question, the higher apes being tree-dwelling forms, whereas man has become almost exclusively a ground-dweller. . . . It is commonly believed [by experts] that the group [of apes] from which man directly descended must have lived, for a short period at least, in trees, as do the present-day apes, but that in the course of time, as man developed more cunning and better means of protection, he left the tree tops and sought the open plains.

In this really excellent chapter (XIII), Professor Fasten presents conclusive evidence showing that man, the chimpanzee, and the gorilla had a common ancestor in a more primitive, generalized ape, or "monkey."

Curiously enough, Mr. Orland Kay Armstrong, author of the article previously cited from *The Popular Science Monthly*, also, after stating that Darwin never thought that man descended from an ape, or monkey, ancestor, goes on to approve of text-books which teach, substantially, that he *is* a product of simian evolution, with "a small tree-dwelling animal resembling the lemur" as his primitive ancestor!

Now, did, or did not, the greatest naturalist of all time, Charles Darwin, ever "contend that man was descended from the monkeys"? Mr. Armstrong says he did not. But suppose we let the Master of Down speak for himself. In the last paragraph but one of his famous sixth chapter of "The Descent of Man" (2nd ed., 1874), Darwin says:

In the class of mammals the steps are not difficult to conceive which led from the ancient Monotremata to the ancient Marsupials; and from these to the early progenitors of the placental mammals. We thus ascend to the Lemuridae; and the interval is not very wide from these to the Simiadae. The Simiadae then branched off into two great stems, the New World and Old World monkeys; and from the latter, at a remote period, Man, the wonder and glory of the universe, proceeded.

Again (in the same chapter):

In forming a judgment on this head with reference to man, we must glance at the classification of the Simiadae. This family is divided by almost all naturalists into the Catarhine group, or Old World monkeys, all of which are characterized (as their name expresses) by the peculiar structure of their nostrils, and by having four premolars in each jaw; and into the Platyrhine group, or New World monkeys (including two very distinct sub-groups), all of which are characterized by differently constructed nostrils and by having six premolars in each jaw. Some other small differences might be mentioned. Now, man unquestionably belongs in his dentition, in the structure of his nostrils, and in some other respects, to the Catarhine or Old World division.

The Catarhine and Platyrhine monkeys agree in a multitude of characters, as is shown by their unquestionably belonging to one and the same order. The many characters which they possess in common can hardly have been independently acquired by so many distinct species; so that these characters must have been inherited. But a naturalist would undoubtedly have ranked as an ape or a monkey an ancient form which possessed many characters common to the Catarhine and Platyrhine monkeys, other characters in an intermediate condition, and some few, perhaps, distinct from those now found in either group. And as man from a genealogical point of view belongs to the Catarhine or Old World stock, we must conclude, however much the conclusion may revolt our pride, that our early progenitors would have been properly thus designated. But we must not fall into the error of supposing that the early progenitor of the whole Simian stock, including man, was identical with, or even closely resembled, any existing ape or monkey.

Yet Mr. Armstrong tells us that neither Darwin, "nor any other scientist, has ever contended that man descended from the monkeys"!

Speaking of the remarkable similarities existing between the body of man and that of the higher apes, Darwin's great contemporary, G. J. Romanes (1848-1894), said:

> Here we have a fact, or rather a hundred thousand facts, that cannot be attributed to chance, and if we reject the natural explanation of hereditary descent from a common ancestor, we can only suppose that the Deity in creating man took the most scrupulous pains to make him in the image of the beasts. [See, in this connection, his *Scientific Evidence of Evolution; Mental Evolution in Animals; Mental Evolution in Man—Origin of Human Faculty.*]

In his well known work, "Prehistoric Man and His Ancestry," Dr. F. Scott Elliott, the British scientist, says:

> According to the interesting essay by Macnamara, even at the beginning of the Miocene period, certain apes had no less [sic] than 170 structural characters in common with man; the giant apes of the Early Miocene had 150 of these common characters, which increased to over 300 in the Mid-Miocene chimpanzee-like form. In the Upper Miocene, in his view, man became a plantigrade animal.

At the present day, according to Sir Arthur Keith, man has 896 characters in common with the chimpanzee, 385 with the gorilla, 272 with the orang-utan, and 188 with the gibbon. (Cf. Schwalbe, "*L'Anthropologie*"; also *Arch. für Anthrop., Neue Folg., Bd.* 3.)

These facts have been demonstrated since Darwin's time, but would have been considered by him as of the utmost significance. It may be added that there are some thirteen minor peculiarities of bone and muscles which occur in the human object only as rare and exceptional abnormalities, but which do occur regularly and normally even in lemurs (Duckworth, "Morphology and Anatomy").

The distinguished American palaeontologist, Dr. John C. Merriam, states that although the known fossil remains of anthropoids are fragmentary,

> The available material is sufficient to show distinctly a considerable range of forms in which there are present characters approaching those of the human type, as well as diagnostic features of the gorilla and chimpanzee. . . .
>
> The primate or man-monkey group was in existence, clearly defined, considerably differentiated, and widely distributed in Eocene time, five periods before the present day, or at the beginning of the stage of dominance of the great mammal group. The anthropoid or ape division of the primates was distinctly represented in Africa in the second or Oligocene period of the mammal age. By the middle of the third or Miocene period, forms having in general the characteristics of the orang and the gorilla are found in Asia, and a representative of the gibbons was present in Europe.

Read now what Prof. Richard Swann Lull, of Yale University, has to say on the question of the ancestry of man and monkey:

> The ancestral stock out of which the primates arose was undoubtedly the Insectivora, some of which, like the pen-tailed shrew, are arboreal. One visualizes, therefore, as the hypothetical ancestor of all primates a big-brained insectivore, with keen senses, generalized teeth, and arboreal in habits, but one whose limbs, while amply fitted for tree inhabiting life, were in no way extreme in their specialization.

Creatures of this sort inhabited the tropical forests of a circumpolar sea, for such relics of an old land mass as now persist, specifically Greenland and Spitzbergen, show from their plant fossils that such habital conditions did exist in early Eocene time. No trace has been found, either of the insectivorous precursor or of the primitive primates themselves, in this northern region, but here vertebrate fossils are very rare. Their simultaneous appearance in both Europe and South America in Lower Eocene sediments is proof of their migration, not from either one to the other, but from some contiguous and accessible area. [See Lull's *Organic Evolution* (1920) and his *The Ways of Life* (1925).]

The ancestor of man did not, it seems safe to say, develop his special traits and structure while still a forest creature. Life in the trees tends to over-specialization, and man is still a more or less generalized and plastic organism. It was probably as a ground-ape that his higher developments occurred—in a plain, or sparsely wooded area, either in Africa or in Asia. To quote Professor Lull on this point (*"Organic Evolution,"* pp. 257-258):

If we seek for the arboreal ancestor, . . . we would not find him in sediments later than the Miocene, and [Joseph] Barrel was inclined to think that the momentous descent from the trees occurred as far back as Oligocene time [in central Asia]. During Oligocene time began a great crustal uplift, culminating in the Miocene and leaving as a record of its occurrence not only the continental elevation as a whole, but the initial growth of the Himalayas that were to cut off the northern and central portions of the continent from the tropical Oriental realm as we know it today. The ancestors of the four great apes must have made the passage southward before the barrier was prohibitive, but they left behind in the primitive home, among other allied types, the ancestors of man. The Miocene uplift had a profound effect upon climate, especially in the induced aridity; it also probably meant a diminution of temperature below that necessary to sustain the tropical forests which primates love. [Cf. Gregory, W. K., "Did Man Originate in Central Asia?" *The Scientific Monthly*, May, 1927.]

Most readers will concede that Sir Arthur Keith is something of a scientist. Yet he insists that "Darwin Was Right." In his address of August 31, 1927, as President of the British Association for the Advancement of Science (to be found in Little Blue Book No. 1299), this eminent anatomist and anthropologist said:

All the evidence now at our disposal supports the conclusion that man has arisen, as Lamarck and Darwin suspected, from an anthropoid ape not higher in the zoological scale than a chimpanzee, and that the date at which human and anthropoid lines of descent began to diverge lies near the beginning of the Miocene period. . . . Prolonged researches made by modern psychologists have but verified and extended Darwin's conclusions. No matter what line of evidence we elect to follow—evidence gathered by anatomists, by embryologists, by physiologists, or by psychologists—we reach the conviction that man's brain has been evolved from that of an anthropoid ape and that in the process no new structure has been introduced and no new or strange faculty interpolated.

Passing from a British authority to an equally renowned American expert, we find the following endorsement of Darwin's surmise that man passed through a monkey stage in his evolutionary development. Prof. W. K. Gregory, of the American Museum of Natural History, and professor of Vertebrate Palaeontology in Columbia University, tells us that, "starting from aboreal tree-shrew-like forms, the primates passed through a stage not unlike the lemurs in many general characters, par-

ticularly of the brain and skeleton, that they then went on to the primitive monkey stage and then, progressing through an upright sitting stage, gave rise to the pro-anthropoids, which in turn gave rise to the diversely specialized recent anthropoids, and to man."

In discussing the extensive embryological researches of Prof. Adolph H. Schultz (of Johns Hopkins University), Dr. Gregory says that his results "even suggest that man diverged from the gorilla branch after the separation of the chimpanzee and that thereafter the gorilla and man rapidly became extremely different, the former becoming quite secondarily a great-jawed, gigantic quadruped, the later, a weak-jawed biped. The characters of the brain, ear, etc., are in harmony with this view." (See Gregory, "How Near Is the Relationship of Man to the Chimpanzee-Gorilla Stock?", *The Quarterly Review of Biology*, December, 1927, pp. 549-560; and Schultz: "Fetal Growth of Man and Other Primates," *The Sun. Jour. of Biol.*, Oct., 1926, pp. 465-521.)

In attributing to the human stock so late a divergence from the ancestral anthropoid—or possibly gorilloid—stem, Dr. Gregory diverges widely from the more recent conclusions of Prof. Henry Fairfield Osborn, honorary curator of vertebrate palaeontology and president of the American Museum of Natural History; also research professor of zoology, Columbia University. Dr. Osborn, in 1927, separated the Hominidae (human family) from the Simiidae (ape family) as far back as Oligocene times, a period when no man-like apes existed, so far as the fossil evidence goes. This scheme would give man and the higher apes a common ("monkey") ancestor, just as much as would the family tree of other (nearly all other) zoologists; but it makes man appear to be less closely related to the existing four man-like apes. In a sense, it makes man more closely related to the monkeys. Instead of being called the Dawn Man Theory, it should be called the Monkey Theory; since at the supposed stage of divergence the great apes had not been evolved. The only difference between the generally accepted theory and Osborn's hypothesis is that the Hominidae are given a longer period of independent evolution. But if this new hypothesis is well-founded, how shall we account for the close anatomical and physiological relationships of man and the chimpanzee and gorilla—and, we might well add, the gibbon and the orang?

Gregory himself suggested that some of the characters common to man and one or more of the anthropods might be due to what is known in zoology as "parallelism," or the independent acquisition of similar characters, due to equivalent environmental conditions and incident required adaptations, after the divergence from a common stock. But such a conclusion could be based only upon pure (though perhaps reasonable) assumptions, hence the burden of proof would rest upon those who would make bold to class all of the many close agreements or resemblances as "parallel" developments, rather than regarding them as inheritances due to a common ancestor possessing the more highly developed similar structures and characteristic physiological traits and reactions. But further discussion of this aspect of the problem must be deferred until later sections of this volume.

Enough has been said, I believe, to show that there is something wrong in the statement so frequently reiterated in press and pulpit and in the lecture hall, that "real scientists" do not claim an ape, or "monkey," ancestry for the human family. And yet even the disavowers frequently wind up by offering the evidences for man's simian ancestry!

After much reading, one finally discovers that what the "reconcilers" really mean is that "no scientist" claims that man is a descendant of any of the *living* anthropoids, or "monkeys"—whatever they may mean by this latter term. But every scientist today knows that the four great anthropoids were descended from some stem form between the insectivorous, generalized mammals of the Cretaceous period, and a form not far different from the earliest Eocene lemuroids, or perhaps, tarsioids, these in turn giving rise to the "monkeys," or proto-anthropoids, and so on, to the true anthropoids and primitive man (*Eoanthropus*)—the real "Dawn Man," the Greek term signifies—or a form close to the earliest completely human forms. The four anthropoid apes and man have had as immediate, and common, ancestor a creature not far removed structurally from themselves—that is to say, the immediate ancestor of man and the four great anthropoids was a very man-like *ape,* differing in no profound essentials from what the branch that was to become man, as we know him, was at that time. In that far-off past the gorilla and chimpanzee and man were so much alike in physical aspects that they would all have been classed—even by a Fundamentalist Linnæus or Cuvier—as apes, if any scientist had been living at the time to make such a generalization!

One branch of these primitive anthropoids was destined to develop the characters and potentialities that resided in all of them, circumstances favoring such a development. Circumstances (increasing aridity and loss of forest area) thus favored only one branch—the to-be human. One of the descendants of the so-called human branch of these apes is writing these lines, and is perfectly willing to agree that he is a more or less highly developed ground ape!

When I study the anatomy and physiology of the great apes of today it is perfectly clear to me that the ancestor of all of us was made more or less "in the image" of some ancient generalized ape, not far different in appearance from the modern gibbon. All zoologists concede that the human race had its origin in some primitive mammal of Cretaceous times. But no scientist can draw us successive pictures of an advancing form leading eventually to *Genus homo* without drawing a few monkey-like forms, leading to higher ape forms—*not* to man first, not even to a "dawn man" of Oligocene or Upper Miocene times. (Read in this connection Prof. Gregory's "Mongolian Mammals of the 'Age of Reptiles'," *Scientific Monthly,* March, 1927, pp. 225-235.)

I should be curious to know how the "anti-monkey" palaeontologists would classify this queer non-ape ancestor man. Would it be a human being, or a plain, every-day ape of a given geological period, with certain human-like attributes? Would this creature not be just about what scientists call the "stem-form" of man—and also of the four man-like apes? If not, how would it be classified? Will some "conciliator"

please explain how we can, even in imagination, skip the "monkey stage," somehow advancing from a lemur to man without ever passing through an ape ancestry?

Now, we have a right to ask of the vertebrate palaeontologist and the comparative anatomist to describe to us the external appearance and the intimate anatomy of this supposed predecessor of the (hypothetical) "dawn man," who was *not* a descendant of any branch of monkeys or apes. (In technical terminology, a "monkey" means a primate below the anthropoid ape stage.) Again, we want to know how it so happens that all the primate fossil remains so far discovered lead directly up to the stem form of man and the anthropoids, instead of to a pre-human form not directly related to the four anthropoids and man.

As a matter of fact, there are no legitimate answers to these questions, and none has ever been offered. What we get in the way of an answer is more or less clever evasions, never a direct, straightforward reply.

The truth of the matter is, as every competent scientist knows, that man himself is, as I have said, an anthropoid ape. He is simply a *fifth* genus of anthropoid—or, as Shipley and MacBride very succinctly and honestly put it, "man is a ground ape" (*Zoology*, p. 714, 4th ed.).

Yet, in spite of all his inexpressible cruelties and imbecilities, man must be accorded the description, "a *glorified* ape." The fact that most men, in comparison with the best of men, do not seem to be very much "glorified," does not refute the fact that, as compared with even the highest anthropoid of the other four genera, man is very much glorified indeed.

Now it remains to prove, by all the available evidence, that what I have just said is irrefutably true. This evidence I purpose to set forth in the pages following.

Perhaps the question will arise in the reader's mind, "How does it happen that we who have read the writing of the world's greatest scientists have not met with some of the statements presented in this book?"

As a matter of fact, if the reader of this volume has really read even a small part of the work of the greatest living scientists, he has read exactly the same conclusions that I have just adduced; only, in some cases at least, the straight truth has been smothered under a veil of technicalities, in order to avoid "hurting the reader's feelings." In this work I am not in the least concerned with the reader's feelings. I am appealing to his or her *intelligence*, to the minds of men and women who are able to look Reality square in the face without flinching. The facts I am presenting are not for those who mistake emotions for thoughts, or egoistic resentment for reasoning. Most "humans" are, unhappily, like this. But there is an appreciable minority of us anthropoids who have developed sufficiently to want to know the facts in evidence, no matter what our traditional emotions about the subject may chance to be.

I do not wish to imply, however, that "soft" methods of approach are not at times, and in certain circumstances, needed. All I contend is

that realistic methods are also needed. "Popularizers" are, I think, abundant enough. What we most require at present, as I see it, are a few more straight-from-the-shoulder writers, thoroughly acquainted with their subject, who do not mince words or dodge issues. Such writers can hardly look forward to fame or wealth from their work; they must be "born that way," and willing to pay the price of their refusal to compromise. Fortunately, there are quite a few of them left—though, perhaps, not enough of them.

Let us proceed now to the *facts*, bearing on this inquiry, derivable from the various departments of natural science.

CHAPTER II

OPPONENTS OF SIMIAN DESCENT

BUT first let us examine more closely some of the arguments of the "anti-monkey ancestry" protagonists.

Although I have asserted that every competent zoologist and anthropologist of today teaches in effect, if not in so many words, that the remote ancestors of man were, as members of the same Order of mammals (the Primates), first lemurs, then successively true monkeys, higher apes (anthropoids), and finally man himself, there appears to be at least one exception: *appears* to be. I refer to Prof. H. F. Osborn.

On April 29, 1927, this renowned palaeontologist and anthropologist celebrated the 200th anniversary of the American Philosophical Society, at Philadelphia, by renouncing—and denouncing—the ape-human theory of descent, of which he had been for many years a very prominent advocate. The ape theory, he told his astonished audience, should be abandoned. "I regard the ape-human theory," he declared, "as totally false and misleading," and he added that it should be "banished from our speculations and our literature"—thus apparently endorsing the position of the voters of Tennessee, Mississippi, and Arkansas, and the Text-Book Commission of Texas!

Having cast aside as practically worthless the grand results of more than a century of painstaking research, we may "resolutely set our faces toward the discovery of our actual pro-human," non-simian, ancestors. These he referred to as "dawn men"—that is to say, the "pro-human ancestors" of man were already men, though at the same time pre-human creatures. This imaginary stock, Dr. Osborn said, was "neither human nor ape-like," but was nevertheless capable of transmitting "certain common attributes" of both apes and man to "variously branching races of human beings on the one hand and to variously branching races of anthropoid apes on the other." A remarkable power, one would think! Though not ape-like, they could yet transmit to the ape their ape characters—a rather novel conception of hereditary processes.

The ape-man theory having been verbally abolished, one is almost startled to read the paragraph which follows, to-wit:

In this very ancient [but non-existent!] man-ape stock (Anthropoidea) resided the affinity which survives today in all blood tests, in peculiar susceptibility to or immunity from certain diseases, in resemblance of the haemoglobin blood crystals, in the uniform division of the teeth to the number of thirty-two, in the extension of the caudal vertebrae into a tail, reversional both in man and apes, and in many psychic characteristics such as curiosity, fear, family protection, and courage. It is not surprising that these and other common ape-human characteristics have survived when we see similar survivals among other animal stocks which we know parted company millions of years ago.

It would, indeed, not be surprising that "these and other common ape-human characteristics" should survive if our ape ancestor had not just been abolished, and a mysterious Dawn Man, "neither human nor ape-like," been put in his place. One cannot but wonder if the hypothetical "dawn men" had ancestors of their own; and if so, whether they were ape-like, of simian descent, a product of "monkey" evolution, or whether, like Topsy, they "just grew."

Granted, for the sake of the argument, that the "prologue and the opening acts of the human drama occurred away back 16,000,000 years ago in the Upper Oligocene period," this extension of the time period does not in the least make it unnecessary that the fancied dawn men should have had a pedigree. We should like to be told something as to their zoological status and their taxonomic position in the evolutionary scale before they became "dawn men." If these ancestors of ours could properly be classed neither with the Simiidae nor with the Hominidae, nor yet with the Hylobatinae (gibbon family) surely they could still be grouped with the Primates; we could not conceivably exclude them from this Order. Since no other families of Old World—dare we say apes?—are known, we are logically compelled to derive the generalized "dawn man" from anthropoid ancestors, which at once restores "the Haeckel ape theory"!

Parenthetically, why the "Haeckel ape theory"? Had not the great Lamarck advanced the "ape theory" before Haeckel was born? And to mention only one other thinker, did not Lord Monboddo, in his "Origin and Progress of Language," in 1773, maintain, as did Darwin in 1871, that man descended from the apes, and that Africa was his birthplace?

Osborn tells us that "*when* [italics mine] we at last discover one of our pro-human ancestors in Miocene or even in Oligocene time, the human characteristics will be found plainly stamped on this ancestor." Possibly; but no more, perhaps, than they are plainly stamped on the baby gorilla, if as much. At any rate, it would appear to be more in harmony with scientific method to describe this dawn man after he has been found, or at least to hold on to "the Haeckel ape theory"—which is at least based upon tangible evidence—until we can find a better basis for our conclusions than a product of the imagination.

When we speak of the common ancestor of the apes and man as an ape, we do not think of an anthropoid closely resembling either man of today or the anthropoids now living. If some persons do, they do so without warrant in fact. Nor can we truthfully speak of this common ancestral form as an ape-man. Personally, I do not know of any scientist who does. An "ape-man" would already have passed onward and upward from the generalized common ancestor of anthropoids and man *as we know them today*. I therefore concede Osborn's point when he states (as it seems to me, superfluously) that:

> It is no more proper to speak of the common ancestor of the apes and of man as "ape-man" than it is to call the common ancestor of the horse and the ass an "ass-horse" ["Recent Discoveries Relating to the Origin and Antiquity of Man," American Philosophical Society Proceedings, Vol. LXVI, 1927, p. 384].

But we can and should speak of the very ancient common ancestor of modern man and the living anthropoids as an *ape*. The term "monkey" should be reserved for the lower type of Primates (but above the lemurs).

Osborn himself, in the address just quoted, says: "I agree with my colleagues that man passed through an arboreal stage, but I believe that this stage did not progress so far as to carry man into a stage approaching that of the anthropoid apes." No, not if by this he means one of the great anthropoids of today—the highly specialized products of 16,000,000 years of forest experience.

Note that in the passage just cited, Dr. Osborn acknowledges that the remote ancestors of man were arboreal animals below the anthropoid stage. Such could be nothing else than monkeys or apes below the stage of development later to be attained as man-like apes. He prefers to call the more advanced apes "dawn man"—that is all.

In *The Scientific Monthly* of May, 1928, Professor Osborn tells us that his Dawn Man Theory of human descent may be expressed as follows:

> Man sprang from partly tree-living (arboreal), partly ground-living (terrestrial) higher primates, of the kind known as "anthropoid" because of their nearer resemblance to man than to the monkeys, baboons, and lemurs. The fingers of the ancestral hand were broad and separated, the thumb well developed, with grasping power; the toes of the ancestral foot, on the contrary, were brought together, and the big toe was slightly separated. Thus in both the hand and foot these pro-human anthropoids were adapted both to tree and to ground progression. Neither hand nor foot was so far specialized for extreme arboreal life as to be disabled for an early tool-making power of the hand and for nearly bipedal and cursorial power of the limbs and feet. Similarly, the pro-human brain conserved the alertness of all smaller primates in the terrestrio-arboreal stage but retained the potentiality of directing separate motions of the fingers and thumb in shaping defensive and offensive weapons, and the potentiality of directing rapid motions of the limbs and feet in bipedal, cursorial life, defensive and offensive.
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> This theoretic picture of adaptation to habit in our Dawn Man and pro-Dawn Man ancestors is, in my opinion, largely sustained by the embryonic, the foetal, and the adult structure of the human hand and foot. These prenatal locomotor organs afford evidence of arboreal adaptation far antecedent to the highly specialized brachiating or limb-swinging hand and limb-grasping foot of the anthropoid apes. In other words, according to the Dawn Man theory the human family branch scientifically known as the Hominidae has since Lower Miocene and perhaps Upper Oligocene time been independent from the ape branch known as the Simiidae or snub-nosed primates. The innumerable resemblances between apes and man in functional, anatomical, psychical, and physiognomic characters are, by the Dawn Man theory, interpreted partly as parallelisms or convergence and partly as heritages from a common stock technically known as the primate Order Anthropoidea.

Hardly a mortal blow to "the ape-man myth!"

Soon after Dr. Osborn had demolished the "ape-man myth," in 1927, the Fundamentalist orators were rejoicing over Mr. Austin H. Clark's repudiation of the theory of evolution as understood by the world of science. That eminent biologist, the late Rev. Dr. John Roach Straton, of Calvary Baptist Church, New York, was "glad to hear a responsible scientist tell the truth for once."

In a very remarkable paper contributed to *The Quarterly Review of Biology,* December, 1928, Mr. Clark, a member of the staff of the Smithsonian Institution whose specialty is marine biology, though he has done work in entomology and ornithology, told the scientific world that all the talk about man's derivation from an ape-like ancestor was in no way supported by the evidence. Man first appeared on the earth just as we see him today, and there are no such things as "links," missing or found.

More recently (September, 1929), Mr. Clark has favored the experts in palaeontology, morphology, etc., with another outburst of biological genius, contributed this time to *The Scientific Monthly,* the title being, "Dead versus Living Men." Here we are assured that "man never was arboreal, and none of his ancestors was ever arboreal . . . . Man never was a monkey." Apparently, he just made one grand jump, saltation, or mutation from "the same general stock as that which produced the monkeys"—no "missing links" being indicated.

Mr. Clark declares that he is not an anti-evolutionist. His theory, he assures us, is, rather, "a harmonizing of previous theories," not a new idea or system. By which he means, apparently, that his ideas combine the Biblical doctrine of special creation and the modern theory of evolution—albeit a much restricted conception of evolution. Man, as such, it would appear, had no anthropoid ancestry; hence the human family does not fit in with any evolutionary scheme. Man must, therefore, be a product of "special creation"—whatever that may mean.

And this is likewise true, Clark tells us, of the major groups of animals, past and present, in respect to which "the creationists seem to have the better of the argument." "There is," says Mr. Clark (I am quoting from his article, previously cited, in *The Quarterly Review of Biology*), "not the slightest evidence that any one of the major groups arose from any other. Each is a special animal complex related, more or less closely, to all the rest, and appearing, therefore, as a special and distinct creation."

That is to say, for example, that the Amphibia could not have been derived from any species of fish; that the Amphibia in turn could not have given rise to the Reptilia, nor the latter to the Mammalia. And no generalized ape of long ago could gradually have evolved into primitive man.

As for the Darwinian phylogenetic tree of animal life, leading from moneron to man, through the billion years or more of geologic time, this concept must be abandoned—presumably in favor of Clark's own startling hypothesis. In short, there has been, according to his theory, no linear descent from the lowest living being—some ancient one-celled plant or animal form—on upward to the higher types. Each of the larger, or major, groups of animals appeared, from the beginning, just as we see it today, as if specially created, once for all.

"But," says Mr. Clark—and now he speaks as an evolutionist—"Within each major group we see a very different picture. Here the

fossil record shows a constant change from one horizon [deposit or layer of earth] to another. These successive variations are probably simply indications of a direct response to physical alterations in environment favoring now one type or subtype, now another."

Here we have an evolution by mere chance, not by special creation: "This continuous alteration in the elements within the various groups is what is commonly known as evolution."

This evolution within each major group (Phylum?) of animals, Clark goes on to say, is best illustrated in the vertebrates, especially in the reptiles and the mammals, through many millions of years, as revealed in the geological records of the earth's strata. "Here we can trace the gradual development from comparatively insignificant beginnings to a wonderful flowering of specialization and perfection."

In this statement, Mr. Clark is of course in agreement with all other scientists of today. It is a matter of fact, not merely of theory, that the most primitive reptiles first appear in the rocks which were laid down, under water, as sand and mud, toward the close of the Carboniferous period. According to the now generally accepted estimates, this period came to an end some 189 million years ago. Then followed the Mesozoic Era, which lasted about 150 million years—plenty of time for even reptiles to evolve *in*!

But where did the original reptiles come from? Had they no ancestors? According to Clark's theory, either the first reptiles "just were there," or they were "created" out of hand, as it were. Between one major group of animals in the ascending series and the next higher the laws of nature were, apparently, suspended, and superseded, for the time being, by a magical process, unknown to science, called euphemistically "special creation."

The scientists of the world today have before them what they regarded as conclusive evidence that the reptiles were derived from the Amphibia, and the earliest mammals from a certain group of mammal-like reptiles. Another group of reptiles, bird-like in structure, is considered the ancestor of the Aves; and the evidence on which this conclusion is based (even fossilized transition forms having been discovered) is, to all but one or two living men of science, overwhelmingly convincing.

Mr. Clark, as we have seen, says that he believes in evolution *within* each major group of animals, but denies (to pass to a problem of more immediate interest in this volume) that man was derived from some ancient, generalized, anthropoid ape. He uses the word "monkey," but this is a term employed by scientists in reference only to the lower forms of the Primates.

Now, if Mr. Clark (as he himself assures us) believes in evolution within each major group, one might well ask how he arrives at the conclusion that man is not genetically related to the great apes. If such major groups as the Coelenterata, Vermes, and Echinodermata are genetically related, and the higher reptiles are descendants of the lower,

how can it rationally be asserted that the Primates—morphologically and physiologically quite as closely akin as the various families among the Reptilia—are not genetically related? This question is especially pertinent with regard to the zoological status of the three great anthropoids (chimpanzee, gorilla, orang) in relation to the greatest of all Simians, proud Man.

Mr. Clark is quoted as having told a staff correspondent of the United Press that "there is no evidence which would show man developing step by step from lower forms of life. There is nothing to show that man was in any way connected with monkeys." He then added the following astonishing statement—a statement that proved to be as startling to the scientific world as to the general public, coming as it did from a government biologist:

> Man appeared in the Pliocene Age, just preceding the Ice Age. He appeared suddenly, and substantially the same in form as he is today. There is not the slightest evidence of his existence before that time. He appeared able to walk, able to think, and able to defend himself. There are no such things as "missing links." Missing links are misinterpretations. Fossil skulls, which have been dug up, have been advanced as missing links, showing connection between man and monkey, but they have all been shown as misinterpretations.

Let us now examine this peculiar statement somewhat in detail.

That man appeared in the Pliocene Period is true—the period preceding the Pleistocene, or Age of Ice, as it is sometimes called. (The Ice Age was not, as many persons still believe, a continuous cold period. The ice sheets appeared and retreated at least four times during this period, between which ice invasions long warm periods prevailed. The Glacial Epoch, with its interglacial warm climates, lasted for about a million years, the last invasion of England, France, Germany, and the United States terminating about 18,000 years ago.) The preceding Pliocene Period lasted for about six million years, ending about a million years ago. We are now living at the beginning of another interglacial period.

Mr. Clark does not tell us whether he thinks man appeared at the beginning of this long period of time, or near the middle of it, or toward its close. He does tell us, however, that man "appeared [in the Pliocene] suddenly and substantially in the same form as he is today."

Now, since no fossil skeletons of man of this period have as yet been discovered—only his hearth-fires and his tools—it is a fair question to ask Mr. Clark how he knows what the *form* of man was in the Pliocene, or that it was the same during all of this long period of six million years as it is today.

Unless the Piltdown Man or the Java Man are of Pliocene age, we have not even a single fragment of the skeleton of Pliocene man. How, then, can Clark know that these ancient human beings had the same form as man of today? We know them only by the crude flint tools and weapons they made, and by the fireplaces still to be seen in the Pliocene strata of East Anglia, in south-eastern Britain, close to the shores of the North Sea. **Must we now add American Pliocene tools?**

In our own country, certain very crude bone and other artifacts have quite recently been found in Nebraska, New Mexico, Oklahoma, and Texas, which may possibly carry us back to Middle Pliocene times —the Nebraska relics, at least, proving that some sort of human beings have lived in North America since about three million years ago. (See Maynard Shipley, "Americans of a Million Years ago," Little Blue Book No. 1325, pp. 4-5; Harold J. Cook, "New Trails of Ancient Man," *Scientific American*, August, 1927, p. 115; *The Scientific Monthly*, May, 1927, pp. 477-478.) Will Mr. Clark tell us that these men were substantially of the *same* form as man of today, or even as man of East Anglia approximately one million years ago?

As a matter of fact, the earliest, or oldest, complete or nearly complete skeleton of a human being so far discovered carries us back to a period of only some 30,000 years ago. And this specimen had by no means the appearance of modern man. It belonged, indeed, to a different species of human being (Neanderthal), still retaining in its anatomy some strikingly ape-like characters never found in modern man. Many other skeletons of the Pleistocene, or parts of skeletons—dozens of them —have been discovered, including a number of fairly complete skulls and skeletons. These fossil relics are of the races grouped under the name "Neanderthal," from the locality where the broken and scattered skeletal remains of this type were first discovered. This race was dominant in Europe and Asia possibly in Africa too—for an unknown period, but completely disappeared some 25,000 years ago. We know precisely the physical aspect of these Neanderthal men. But the Pliocene man of East Anglia and of Nebraska lived hundreds of thousands of years earlier. What does Mr. Clark know of their anatomy or of their stage of mental evolution? Obviously, nothing, excepting that they made crude tools of bone (harking back to the Nebraska artifacts).

It is quite possible, and some geologists and anthropologists think it highly probable, that the primitive skull found in Sussex, in 1911, known as the Piltdown Man (*Eoanthropus*), belonged to the Pliocene period. If so, he may have been a contemporary of the Foxhall flint workers of Ipswich. The Foxhall industry is not so old as that of the Bramford quarry, also of Ipswich; but these Foxhall and Bramford weapons and implements were found in what competent geologists regard as Pliocene strata—but are much later than the Nebraska bone artifacts—perhaps a few million years later!

Now, if Mr. Clark is of the opinion that the Piltdown Man of Sussex is of the same species of *Genus homo* as modern man, and was of the same form and aspect as man of today, it is just as well that he did not elect anthropology as a major study! He should stick to crinoids, on which invertebrates he speaks with authority.

As a matter of fact, the skull of the Piltdown Man—as also of the Trinil Man of Java—is so divergent from that of modern man that some authorities do not regard it as at all likely that this race is in the direct line of ancestry of our own species (humorously named *homo sapiens*), but think that it is rather a side-line, or branch, of the human

family tree. We have so far only a few fragments of this type of man. He is remarkable for his likeness to the chimpanzee in respect to the lower jaw and front teeth, while the shape of the chin is unlike that of man but is almost identical with that of a young chimpanzee. The canine teeth are much larger than those of modern man, and the canine of the lower jaw interlocks with its opposing teeth, as in the apes. But two of the molar teeth, which still remain in their sockets, are distinctly human in form and structure. A skull which somewhat approaches the Piltdown type was found in a river deposit at Talgai, in Queensland, Australia. But the Java Man is still more widely divergent from man as he is today.

By the Java Man I mean, of course, the famous non-missing link found near Trinil, Java, and named, by the discoverer, *Pithecanthropus erectus*. The skull-cap of this specimen is indeed so nearly akin to that of an ape that it is difficult to think of it as having ever covered even the most primitive human brain. But the thigh bone and a few teeth found in the same stratum (and therefore of the same geologic age) are apparently those of a human being, despite the low development of the associated skull. There is no good reason to doubt that these fossil remains once belonged to the same individual who functioned under that flat, ape-like skull-cap. The creature stood fully erect, as attested by the long, straight thigh-bone.

Recent evidence indicates that the various species of early man did not all develop the parts of the body uniformly in the direction of modern man. In some fossil specimens, as in the case of *Eoanthropus*, the skull and brain developed in advance of the jaws and teeth, which remained ape-like; in others the contrary was the case. In all of the older specimens, the parts of the brain which were best developed were the centers in control of mere animal activities; while the fore-brain, the parts of which are highly developed in modern man, having to do with what we may call intellectual or reasoning processes, remain relatively undeveloped, no matter what the size of the brain is as a whole. The Neanderthal race, or races, had a large brain; but hardly any forehead, and no true chin, with ape-like jaws and mouth—almost a muzzle in appearance. Neanderthal Man could not stand fully erect, his thigh-bones being curved forward, and the head and neck habitually bent into the same curvature as the back, as in the anthropoid apes, particularly the chimpanzee.

The Crô-Magnon race which succeeded the brute-like Neanderthals in Europe, some 25,000 years ago, probably as immigrants from Asia, had large brains with a splendid frontal development. In this fine race we meet for the first time men and women who were physically, and perhaps mentally, the equal of man of today. They were the culminating point in the physical evolution of man, the product of millions of years of human development. A million years, approximately, had passed between the time of the earliest tool-makers of East Anglia and the apparently sudden appearance of these cave-artists in France and Spain. Geologically speaking, as time is measured by the palaeontologist, this race belongs rather to our own times than to those of the Pliocene Man of Sussex. Compared with the remote period of the latter, the Crô-

Magnon race lived but as yesterday! They, and they *alone*, of all the very ancient races whose fossil remains have thus far been discovered, were "substantially" the same in form as man of today.

But we are not wholly dependent upon the mere chance of finding fossil human remains here or there in order to trace the origin and evolution of the human family. There are many other lines of research that point unerringly to man's simian ancestry—evidence which the immortal Charles Darwin was first to assemble and interpret correctly.

Since Darwin's death in 1882, tens of thousands of facts unknown to that great naturalist have been discovered and made available to students. These data are equally available to Mr. Clark; but he seems to have preferred to ignore the major part of the most important facts available to him. Or perhaps he is not acquainted with the now overwhelming evidence for evolution, and against special creation, whether as "major groups" or as "each after his kind." There is no more evidence for special creation than there is for special destruction. Yet, in his desire, apparently, to reconcile the ancient myth of special creation with the results of modern research, he tells us that man appeared on earth substantially as he is today, "to all intents and purposes a product" of that same utterly unproved special creation!

Now, man could have appeared on earth substantially as he is today only by magic, and science knows nothing about the art of magic, white or black. If Mr. Clark's ideas are correct, then we must envisage a most remarkable event, occurring in the early Pliocene Period. No man-like ape or ape-like man roamed the plains or dwelt in the forests. No creature even approaching the status of man existed, for, says Mr. Clark, "there are no missing links," no transition forms from the higher apes to the lowest humans. Those we have discovered are only "misinterpretations." Then, mayhap on a bright sunny day, or perhaps during a thunder storm, with lightning flashing and winds driving heavy sheets of rain—lo! there stand a man and a woman, just as they are today! Poor orphans—no father, no mother, no ancestors, no tribal elders to teach them the ways of nature and the art of living as human beings: there they stand, "to all intents and purposes a product of special creation"—in other words, of magic!

A beautiful picture-book story for infantile minds. Beautiful, but as yet incomplete. Mr. Clark neglected to add the approaching stork with a more diminutive "special creation" wrapped up in a napkin!

Surely this new theory should appeal to our friends of Fundamentalist persuasion, who will not divine its anti-Genesaic implications and its involved doctrine of chance "creations". Dr. Straton, as we have seen, has already honored Mr. Clark with his endorsement. "The whole evolution propaganda is the most gigantic bluff in the history of the human mind," he pronounces further. Why talk of evolution when we have been told by some unknown poet of the Orient that man was specially created from a lump of clay, and woman fashioned from a bone?

The world of science now waits with bated breath for the verdict

of those other eminent authorities on evolution, Billy Sunday, W. B. Riley, and Aimee Semple McPherson!

In his excellent book, "The Stream of Life," Prof. Julian S. Huxley remarks on the curious psychological fact that so much absurd prejudice has been aroused by the discovery that man has evolved from an ape-like ancestor. That man could have achieved as much as he has, from such a beginning, is most encouraging. For such an origin implies that

man *advanced* during his evolution; whereas, for instance, the beliefs of the ancients that men were descended from gods or demi-gods, or that in the beginning was a golden age, or indeed the literal acceptance of the story of Adam and Eve and the fall of man, all equally obviously imply that present-day humanity is degenerate. One would also imagine; especially in a democratic age, that what man is and may become would count for more than pride of ancestry. . . .

Either Nature is meaningless, and the appearances which she thrusts beneath our eyes are not facts at all but deliberate lies, or else man is more closely related to the existing anthropoid apes than to any other creature, and at one stage in his evolution had an ancestor who would have to be classified in the same group as they.

There are very many different lines of evidence that lead us logically and inevitably to Darwin's conclusion that, to quote his own words, "Man is derived from some member of the Simiidae"—that is to say, some member of the ancient anthropoid apes. One could all but *prove* men's *kinship* with the higher apes, even with those still living, by comparative physiology alone, or by morphology alone, to say nothing of palaeontology, or some other lines of evidence.

Mr. Clark, as we have seen, believes that the alternative to the special creation of man is chance variation—an exaggerated case of the mutation theory of the great Dutch botanist, Hugo de Vries. But, he says further, this mutation, or sudden transformation, was not from an ape-like man, nor yet from a man-like ape. Such a view of evolution can only land its author in logical absurdities.

CHAPTER III

COMPARATIVE ANATOMY OF APES AND MAN

WE have just seen how Austin Clark, following Osborn's lead, has dogmatically asserted that man was never an arboreal animal. (Osborn has lately abandoned his non-arboreal hypothesis). For light on this problem we must go to the comparative anatomist. For we have no fossil remains of the arms and hands of the higher anthropoids, much less of their musculature and visual organs with their attachments. But the surviving arboreal, or largely arboreal, anthropoid apes we still have with us. Three of the four man-like apes are still essentially tree-living creatures; but the mountain gorilla, as proved by the lamented Carl Akeley, is to a great extent a ground ape. (Dr. Harold C. Bingham, of Yale, sailed for Africa in June, 1929, where he is making a first-hand study of the mountain gorillas of Belgian Africa. Dr. Gregory, also, is there.)

Now, if man was once an arboreal ape, for even a relatively short time—say a few hundred thousand years—he would still exhibit some reminiscences (or vestiges) of this stage in his development, though escaping from a forest life early enough to avoid the over-specialization (or adaptation) incident to millions of years of tree-dwelling. This is what our greatest American authority writes on this aspect of our problem. Discussing "The Relationship of Man to the Chimpanzee-Gorilla Stock" (*Quarterly Review of Biology,* December, 1927, pp. 537-558), Dr. W. K. Gregory remarks:

> The myology and osteology [study of the muscles and bones respectively] of the whole pectoral limb [arm] of man constitute a veritable palimpsest, bearing a clearly decipherable record, first, of an earlier period when every bone and muscle was adapted for the habit of supporting the body weight by the uplifted arms, and secondly, of a later stage when the arms were no longer used for locomotion but for the support and manipulation of objects held in the hands. Obviously it is not necessary to infer that in the ancestral anthropoid the extreme specializations for brachiation [swinging from limb to limb] had already taken place. Great difficulty has been experienced from the fact that in modern man the arms and hands are relatively shorter and the legs relatively longer than in modern apes. This failure to realize that readjustments of proportions have constantly been taking place, especially when profound changes of function were involved, thus leads to the error of expecting a generalized ancestral stock to exhibit the specialized proportions of some one of its remote descendants. Also, Schultz has cited embryological evidence tending to show that the lengthening of the legs in man is a relatively recent acquirement, perhaps correlated with the ground-living cursorial habit.

As long ago as 1920, Professor Gregory ("*Notharctus,* an American Eocene Primate") showed that at least as far back as Middle Eocene times (some forty million years ago) the arboreal stamp had been impressed upon the hind feet in the three dominant families of

lemuroids and tarsioids in which these parts are known; and no palaeontological or morphological evidence has ever been brought forward to prove the existence of any infra-human primates either of the Eocene or of later ages that did not have clear marks of present or past arboreal adaptations in the hind foot. That is to say, all families of the order of Primates possessed a biramous, or clasping, type of hind foot, with a powerfully developed great toe—"already foreshadowing the great toe of man in its basic anatomy."

In his memorable address, "Were the Ancestors of Man Primitive Brachiates?" read at the meeting of the American Philosophical Society, April 20, 1928 (published in the *Proceedings,* Vol. LXVII, No. 2), Dr. Gregory showed that as we pass from the Eocene and recent lemuroids and tarsioids to the South American monkeys, Old World monkeys, anthropoids, and man,

> we observe on the whole a progressive reduction in the prominence of the peroneal [near fibula] process of the hallux [great toe] and a corresponding improvement in the ability to draw the hallux from a position of wide divergence to a position more nearly alongside the outer digits. Of course one might assume arbitrarily that the series ran the other way, that the human foot is the most primitive and the Eocene *Notharctus* foot the most advanced; but such an assumption besides being dead against the palaeontologic record as it stands, must ignore all the other evidence tending to show that the general progress in the evolution of the teeth, jaws, skull, brain, reproductive organs and many other parts, has been from Eocene lemuroids to primitive monkeys to primitive anthropoids to man. In short, all the facts known to me at the present time support the conclusions of 1916 to 1920 that the Primates as an order stand far apart from the terrestrial placental mammals, that the biramous type of hind foot was first evolved in the very remote tree-shrew-like ancestors of the primates in Upper Cretaceous times, that this biramous hind foot became the starting-point for the extensive deployment or adaptive radiation of the feet in response to the many different methods of locomotion assumed in lemuroids, tarsioids, New World monkeys, Old World monkeys, anthropoids, and man.
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> To come at once to the main issue, the human foot itself appears to bear indelible traces of remote arboreal origin. What other valid explanation has been offered of the fact that in spite of millions of years of later terrestrial adaptation the foot of man is still from a morphological viewpoint distinctly biramous in the arrangement of its musculature, in the length and dominance of the great toe, in the presence of flat nails on all the digits, in the transmission of the weight of the body along two diverging streams, the scaphoid [boat-shaped] stream on the inner and the cuboid [square] stream on the outer side of the foot? I therefore can find no logical alternative to the conclusion that man like all other known primates is a descendant of forms with a typically primate biramous type of hind foot which was evolved during the enormously long ages preceding the stage of terrestrial bipedal progression.

These facts certainly do not support the view of those biologists who would seek to give man an independent, non-arboreal lineage. Dr. D. J. Morton ("Evolution of the Human Foot," *American Journal of Physical Anthropology,* Vol. 7, No. 1, pp. 1-52, 1924; and Vol. 10, No. 2, pp. 173-203, 1927), in particular, has forcibly shown the profound agreement of the human foot with the brachiating anthropoid type.

For several years, Professor Osborn was strongly inclined to the belief that his hypothetical Dawn Man could never have developed the brachiating habit and then escaped from it later on by the adoption of

a cursorial terrestrial life. If I do not misinterpret his more recent writings, he has retreated from this position. If the habit of brachiation—a useful term introduced by Sir Arthur Keith—can produce certain anatomical adaptations, the habit of bipedal locomotion on the ground, if persisted in long enough, can effect even reverse changes, in accordance with Anton Dohrn's classic doctrine of "change of function." Dollo's so called "law of irreversible evolution" has its limitations. There is no proof that the present foot of the chimpanzee or the gorilla could not, in a million years, or less, become fully adapted to comfortable terrestrial locomotion. Osborn himself has recently delivered an address on "The Influence of Habit in the Evolution of Man and the Great Apes" (*Bulletin* of the New York Academy of Medicine, 2nd Series, 1928, Vol. IV, pp. 216-230), in which he declares that "Habit is king." He continues:

> It is prolonged habit alone, after centuries and thousands of years, which determines the rise and decline of parts. Every great group of animals, including the anthropoid apes and man himself, tells this story. Man, particularly, molds and modifies his form by his habits, his mode of living; different races of man, through prolonged and repeated choice of one mode of life or another, mold their racial anatomy. . . . The structure of apes, like the structure of man, is an intensification and perfection of habit.

He then refers to the recent researches of Professor Morton, of Yale, on the foot of the gorilla, where it is clearly shown that the baby gorilla is born with what might be called an arboreal type of foot, yet "the adult gorilla, owing to his walking about on all fours, with his tremendous weight on his feet, gradually loses the distinctively gorilla type of foot; the big toe approximates the other toes, so that in the adult gorilla the foot is much more human-like than in the young gorilla."

The cast of the foot of a mountain gorilla secured by Akeley was so markedly human-like that the late Sir E. Ray Lankester refused to accept it as genuine, not ever having seen the foot of an ape of this variety before. But, conversely, the foot of a human foetus of the ninth week, figured by Professor Schultz, recalls clearly the anthropoid type in the wide divergence of its great toe from the others.

Quite contrary to the views formerly (if not at present) held by Osborn—Gregory, Keith, and Morton regard the habit of brachiation, at least in its early stages, as essential to the progress of the ape toward the human form. It is, they say, the only way of turning the vertebral column at right angles to its former horizontal position and thus of initiating the possibility of erect progression on the ground. But, replied Osborn, brachiation leads to the reduction and loss of the thumb, and since, as he then thought, evolution even in this respect is irreversible, and man's thumb is not reduced, he cannot be derived from a brachiating anthropoid. But Gregory was not so easily convinced. He pointed out that the siamang's thumb—the large black gibbon of Sumatra—after millions of years of extreme tree climbing and swinging from limb to limb, is well developed, and that the mountain gorilla's thumb is a powerful though somewhat short digit. He observes:

It is only in the excessively specialized orang and to a less extent in the chimpanzee that brachiation is associated with some reduction of the thumb. Thus in this siamang [shown in his accompanying illustration] the thumb length is 56.6 per cent of the total hand length from the tip of the middle finger to the proximal end of the palm, while in this orang the thumb length drops to 44 per cent. In this man the thumb length rises to 67.7 per cent of the total hand length.

Now all admit that the thumb is a functionally dominant structure in man's hand and that its dominance is somehow connected with man's increased brain power. Has any valid evidence been presented against the view that man's thumb, like his brain and his great toe, has enjoyed both a relative and an absolute increase in size? . . . In spite of the fact that the chimpanzee and the gorilla now walk on bent knuckles, their hands are unmistakably true hands and not merely front feet; and the brachiating anthropoids are the only known primates which closely approach man in this respect. And by as much as the human hand resembles those of the brachiating chimpanzee and gorilla, internally as well as externally, by so much does it differ from the hands of the primitive pronograde [flat-walking] monkeys, either of the Old World or of the New World. In the foetus it is true that the human hand is shorter than the gorilla hand, but that shows only that many generic differences arise in the foetal stages, as modern embryologists well understand. . . . In fact the differences between the human hand and the gorilla hand are far less profound than the differences between the human foot and the gorilla foot.

(The reader who desires to know, in detail, the many peculiar and significant morphological agreements in the anatomy of the hand between man and the chimpanzee and gorilla, and in other parts of the anatomy as well, would do well to consult Charles F. Sonntag's great work on "The Morphology and Evolution of the Apes and Man" [1927], *Contributions to Embryology*, No. 101, Vol. XIX, Carnegie Institution; and Sir Arthur Keith's paper on "The Adaptational Machinery Concerned in the Evolution of Man's Body," Supplement to *Nature* [London], No. 2807.)

As previously remarked, no single specimen of the hands and feet of man's ape progenitors has so far been discovered, and so we have no way of knowing the relative length of thumb and hand when he descended to the plains as a ground-ape. But even if the thumb had become relatively shortened, natural selection would have favored every variation in the direction of increase in its length. Relying on the assumed "law" of irreversible evolution, Osborn contended that the thumb once shortened would not again gain its original length. But examples of such reversible evolution are not wanting, as pointed out by Gregory. He cites, by way of illustration, the harbor seal (*Phoca*). In this mammal the forefoot has become transformed, by change of function, into a flipper, as in the case of the whale and of a number of marine reptiles of ancient days. But the point of special significance in the case of *Phoca* is that the thumb is now far longer than the other digits, thus serving as a support to the border of the paddle. Similarly, in the hind foot, both the great toe and the fifth digit have greatly increased in length and strength. On Osborn's view, this lengthening of a once short digit could not have occurred, since it is an example of "reversible" evolution. Of course, it may be argued that we do not know the early stages in the seal's transformation from a land quadruped to the marine stage, no fossils having been discovered so far to fill in the earlier palaeontological history. However, as Gregory points out:

The evidence from the brain and many other parts of the anatomy sufficiently proves that the seals are descendants of terrestrial placental carnivores of normal quadrupedal construction. But this in turn clearly implies that in the terrestrial ancestors of the seal the thumb and great toe were shorter than the other digits, as they are in all known carnivores. The "irreversibility of evolution" has therefore not prevented a profound remodeling and change of proportions in the relative lengths of the digits following upon a change of function. In man the increased length of the thumb and great toe appears to me to be just as secondary as it is in the seal.

If any part of man's anatomy should bear testimony as to the possibility of man's origin from brachiating ancestors, it ought to be his entire pectoral limb. In the brachiating apes the fore limbs subserve primarily the function of locomotion, but in man they serve chiefly for the manipulation of tools and weapons and the carrying of loads. Consequently whatever resemblances they may show are in spite of different functions.

Gregory, Keith, and other high authorities have shown clearly that man still retains in his anatomy and musculature, even in the arrangement of his viscera, the proofs of his former brachiating habits. (On this point see, in particular, Keith's important but rather technical paper, "Man's Posture: Its Evolution and Disorders," *British Medical Journal*, March and April, 1923).

Keith has shown that when we pass from the monkeys to the gibbons, which are regarded as having a position at the base of the anthropoid series, we find that this genus of apes has, even without abandoning life in the trees, effected profound readjustments of the viscera and skeleton to its habit of sitting upright and also to its need for an upward extension of the arms and leaping from branch to branch, or tree to tree, sometimes covering a distance of 40 feet! Keith's studies brought to light the fact that, on the whole, the gibbon is nearer to man in this internal readjustment to the upright position than it is to the lower primates. When the lower primates leap or run they do so after the manner of quadrupeds, the vertebral column being held nearly horizontal. In the more ancient primitive forms, there has been found no evidence of ischial callosities, hence it is reasonable to infer that they did not customarily sit upright as do the monkeys and apes of the Old World. The chimpanzee, whose ancestors were already a widespread and numerous tribe in Miocene times, no longer holds its body in a horizontal position, and in sitting and squatting the backbone is rotated upward at 90° to the primitive horizontal position and the head is comfortably balanced in this once difficult position.

It is quite possible, if not probable, that the direct ancestors of man had never developed hands and feet as well adapted to arboreal life as were those of their forest allies. If this is true, it may have had some influence, at least, in their more ready adaptation to terrestrial life when the forests began to thin out, upon the approach of arid conditions. A more or less erect attitude could readily have been established even during arboreal days, and the transition to ground life was undoubtedly at first a slow process, partially prepared for in advance. Ground-living alone does not necessarily convert a primate, as such, into a biped, or even into a partial biped. It might, under certain conditions, have an opposite effect, as in the case of the baboons. In the second

chapter of his "Descent of Man," in treating of man's "manner of development," Darwin truly says:

> As soon as some ancient member in the great series of the Primates came to be less arboreal, owing to a change in its manner of procuring subsistence, *or to some change in the surrounding conditions* [italics mine], its habitual manner of progression would have been modified; and thus it would have been rendered more strictly quadrupedal or bipedal. Baboons frequent hilly and rocky districts, and only from necessity climb high trees; and they have acquired almost the gait of a dog. Man alone has become a biped, and we can, I think, partly see how he has come to assume his erect attitude, which forms one of his most conspicuous characters. Man could not have attained his present dominant position in the world without the use of his hands, which are so admirably adapted to act in obedience to his will. Sir C. Bell insists that "the hand supplies all instruments, and by its correspondence with the intellect gives him universal dominion." But the hands and arms could hardly have become perfect enough to have manufactured weapons, or to have hurled stones and spears with a true aim, as long as they were habitually used for locomotion and for supporting the whole weight of the body, or, as before remarked, so long as they were especially fitted for climbing trees. . . . For many actions it is indispensable that the arms and upper part of the body should be free; and he must for this end stand firmly on his feet. . . . It accords with the principle of the division of physiological labor, prevailing throughout the animal kingdom, that as the hands become perfected for prehension, the feet should have become perfected for support and locomotion. With some savages, however, the foot has not altogether lost its prehensile power, as shown by their manner of climbing trees and of using them in other ways.

I have myself seen an armless man play the piano with his toes. But perhaps the most remarkable illustration of the prehensile powers still latent in the feet of man is that afforded by Miss Martha Hale, a graduate of the University of California, and now a social worker. She was born without arms, and taught herself to be self-dependent. During the war she "did her bit" knitting socks. There was no one to tell her how. She was obliged to knit them inside out, and they were accepted by the Red Cross. If you happen to dine with her, she may slip her feet from her slippers, pull back her stockings (which are slit the length of her toes), and pass you the menu! To handle glasses and cups she uses both feet, but she takes hold of sandwiches easily with two toes. She undresses herself faster than many another woman, though it takes her longer to dress than it does women who have the great advantage of arms and hands. Books are as deftly taken from her bookcase as anyone could "pick them out." In short, her feet now function as hands as well as locomotor organs, a striking example of the effects that can be produced by habit (use) and change of function. Ina Hanson, a young dancer, recently signed a movie contract with her toes. And she has perfectly good hands.

As for the anthropoid apes, they are now in an intermediate condition, but, as Darwin observed, "approach in structure more nearly to the bipedal than to the quadrupedal type," and "no one doubts that they are on the whole well adapted for their condition in life." Given man's stereoscopic vision, erect posture, and ability to grasp an object in his hand and thus to examine and test it and to fashion tools and weapons for his own use, it is not difficult to account for his brain development, and for his becoming earth's dominant animal form. Here is something to ponder on: Prof. A. S. Romer, of the University of Chicago, remarks:

Suppose ourselves, for the moment, possessed of our proper intelligence, but having the body of a dog or that of a horse. Of what use would be man's superior intelligence if he were unable to make or use the simplest form of tool or mechanism? . . . The difference which we may list between man and the higher apes are differences which are almost entirely related to the erect gait of man upon the ground and the mental development which seems to have arisen nearly simultaneously ["Evolution of the Vertebrata," Chapter XI in "The Nature of the World and of Man"].

Prof. Thomas Cheny, of the University of Melbourne, made the interesting suggestion, a few years ago, that man may have found on the seashore a proper environment for his further development. The recognition of shellfish as food demanded some intelligence, especially the distinction between wholesome live molluscs and dead ones. To quote a few points only:

This function, together with the new uses for the hand and foot, would further develop the brain, and thus the brain became the organ of survival-value. As the shellfish could not fight or run away, there was no call to develop great teeth, swift legs, or any other organs of attack and defense. The sands are clean, soft, and free from insects, so that the new primate did not evolve callosities, nor did he become immune to disease in the way that the lemurs and monkeys have done[?]. Proto-man may have cracked shells with a stone instead of using his teeth. Seashore food is nitrogenous, soft, nutritious, and requires little mastication. Man's third molar is decadent; human babies can digest oysters, but not bananas, coconuts, or the cereals. All these are facts, and there may be a causal relationship between them.

Darwin noted that it was especially animals that lived entirely or spent much of their time in the water that possess naked skins. He surmised (*Loc. cit.*):

Whale and porpoises (Cetacea), dugongs (Sirenia), and the hippopotamus are naked; and this may be advantageous to them for gliding through the water; nor would it be injurious to them through the loss of warmth, as the species which inhabit the colder regions are protected by a thick layer of blubber, serving the same purpose as the fur of seals and otters. Elephants and rhinoceroses are almost hairless; and as certain extinct species, which formerly lived under an Arctic climate, were covered with long wool or hair, it would almost appear as if the existing species of both genera had lost their hairy covering from exposure to heat. This appears the more probable, as the elephants in India which live in elevated and cool districts are more hairy than those on the lowlands. May we infer that man became divested of hair from having aboriginally inhabited some tropical land?

Darwin then brings forward some pertinent objections to the proposed inference, and cites Belt's view (given in the latter's "Naturalist in Nicaragua," p. 209, 1874) that "within the tropics it is an advantage to man to be destitute of hair, as he is thus enabled to free himself of the multitude of ticks (acari) and other parasites, with which he is often infested, and which sometimes cause ulceration." The problem being so obscure, the great naturalist falls back on his theory of Sexual Selection as the most probable explanation. The suggestion that peoples who spend much of their time in salt water tend to be, or to become, in time, relatively hairless, would seem to be worthy of further investigation. But the question would at once become involved with the climatic factor, for persons who live in temperate and colder climes do not spend much

of their time in the water, fresh or salt. Are they more hairy—on the average, than southerners?

Allusion has already been made to the importance of acute vision to the apes and man. In all the orders below the Primates, the olfactory organs play a most important part (birds excepted). They literally smell their way through life. Hearing, however, is a close rival to the sense of smell. To a tree animal the problem at any moment is not so much "*what* is it?" as "*where* is it—in the tree or on the ground, and, in any case, what is its position?" The problem of the distance to the next branch becomes important; and, in the case of the gibbon, particularly, the strength of the distant limb must be estimated by looking at it, "sizing it up," just as man would need to do. Hence improvement in the organs of vision and in the brain must go hand in hand.

In the lowest stage of primate evolution, represented by the lemurs, the nose is still as important an organ in the struggle for existence as the eye. The eyes in the primitive stage are directed outward and forward. In the Eocene period there lived as an ally of the ancestral lemur *Notharctus* a little primate whose fossil is known as *Tetonius,* the earliest representative of the group Tarsioidea, which has affinities with the Lemuroidea, but is more advanced in several respects. *Tetonius* is remarkable for its relatively large, rounded brain-case and a small face. It possessed the largest brain relative to its weight of any known Eocene animal. A close relative of this interesting little creature was almost certainly the direct ancestor of the queer little nocturnal, monkey like *Tarsius spectrum,* of the Sunda Islands (Malay Archipelago). This is the same region in which the gibbon and orang are living, and where, many thousands of years ago, *Pithecanthropus erectus* (the Java or Trinil Man) made his way along the Solo River. In *Tarsius* the large eyes are directed forward, as they are in a monkey or a human being; not sidewise as in the lemurs. Here we meet with a creature possessed of a close approach to binocular vision, the power to observe an object with both eyes at once.

Sight has now for the first time (in the ancestral *Tetonius*) supplanted smell as a dominant sense. It is believed, however, that *Tarsius* cannot completely focus its two eyes on an object, hence is unable to get the sense of depth (stereoscopic vision). It is, furthermore, believed that *Tarsius* cannot make out the finer details of an object.

Nevertheless, *Tarsius* resembles the higher primates and man more than it does the Lemuroidea, showing important advances in the structure of the brain, and of the external ear, and in the method of forming a discoidal (disk-shaped) placenta, connecting it very closely with the South American Capuchin monkey. In the anthropoidea the orbit of the eye is completely separated from the temporal fossa by an inwardly projecting sheet of bone. In *Tarsius* the structure known as the post-orbital bar, while splayed out, does not quite prevent communication between the orbit and the temporal fossa; whereas in true monkeys, apes, and man, the orbit is completely shut off from the temporal fossa. Of the original five bones around the eye, three (the pre-orbital, post-frontal, post-orbital) had been eliminated by the time of the earliest

mammals, so that man and the apes inherit only two of the original five, namely, the lachrymal and the jugal or malar (Gregory). Today, so far as is known, the eye of the lowest true monkey is as well developed as is that of man. However, see on this question Nadie Kohts, Report of the Zoöpsychological Laboratory of the Darwinian Museum (In Russian), Moscow, 1921; or a German translation of the summary of his report of 1923, published in Moscow. Mrs. Kohts experimented with a young chimpanzee in an attempt to measure his ability to detect and react appropriately to color, brightness, form, size, and number—the most nearly complete study of the psychobiology of vision in an ape so far made.

CHAPTER IV

THE APE IN MAN

IT is a curious manifestation of the average man's slavery to tradition and to his childish egotism, that while he may stand ready to accept the statement of a competent authority that the higher apes were evolved from a lower form, he becomes indignant with foolish pride when told that Man himself has been evolved from the same mammal root or stems as the higher apes.

He will, of course, also persist in contorting this perfectly clear statement into the quite erroneous claim that evolutionists teach that Man has developed from one of the species of monkeys seen in our zoological parks.

On the other hand, we witness today a most deplorable lack of candor on the part of many writers concerning man's simian ancestry —and, in the last analysis, monkey ancestry. This evasive, not to say cowardly, attitude on the part of men and women who should and do! —know better has not escaped the attention of the scientists of Europe.

In at least one of the text-books used in the secondary schools of California the direct statement is made that "evolution does *not* teach that man is descended from a monkey."

As mentioned in my book of 1927 ("The War on Modern Science," pp. 242-243), the question of endorsing certain science text-books used in California was passed on, in 1925, by the State Board of Education, to the presidents of nine California universities—six of them under denominational control. This committee approved the books in question, finding that they contained "no statements derogatory to the Bible," the writers having "taken special pains to assure the readers that there is no conflict between science and religion." The word "Christianity" was side-stepped, but, doubtless, it was intended to imply that Christianity is synonymous with "religion." But it was found that all the authors whose texts were examined showed "due respect and consideration for the fundamental principles of religion, *as presented in the Bible*" (italics mine).

As a matter of fact, it should be of no concern whatever to the teacher of zoology whether or not the findings of science "harmonize" with the mythology of the Egyptians, Babylonians, Persians, or ancient Hebrews. Our tax-supported schools are, legally at least, strictly secular institutions, and their teachers are not hired as apologists for Christianity. The facts as now known lead inevitably and unequivocally to the conclusion that man was not created in the image of a god in a legendary Garden of Eden, but that he is a product of millions of years of gradual

evolution, from some generalized anthropoid stock, and, more remotely, a "monkey" stock—however the word "monkey" may be defined.

It was highly gratifying to see *The Scientific American*, in 1925, in an editorial signed by Mr. Albert G. Ingalls, come out in a straightforward manner on this topic. That Mr. Ingall's still pertinent remarks may reach a wider audience, I quote a few passages below:

Are we always to go on compromising with expediency concerning what we teach about man's ancestry? Are the scorning shafts of the Fundamentalists so sharp that they drive us to refuge behind equivocation? Would the future right to teach the truth about science be jeopardized by teaching now that man's ancestor was an anthropoid ape, and earlier still was practically a monkey? Must we, to be specific, go on asserting in lectures, in magazine articles, in popular primers of science, and even in high school text-books, the technically true but decidedly misleading catch phrase that "man did not descend from any *known* monkey, but that man and the monkeys are only collateral descendants from a common ancestral stem"?

True it is that man did not descend—could not possibly have descended—from any of the living monkeys, and true it also is that both man and the living monkeys descended from a common stem. These statements do not, however, come near representing the whole truth candidly. The common stem was itself like a monkey and later like an anthropoid ape.

However, it is difficult to pin down the loose term "monkey," since few people think of the same group of primates when that word is spoken. According to the Century dictionary, the word "monkey" includes in its content all of the order of primates except man and the lemurs. The word "ape" agrees in its general sense with the word "monkey," but is more limited in its specific sense. In its technical sense, prefixed by the word "anthropoid," it has reference, usually, to the family of the Simiidae, that is the gorilla, the chimpanzee, the orang, and the gibbon.

In any case, the question regarding which particular genus of the order of primates any given person regards as monkeys—whether the Simiidae, which I find is the mental equivalent of "monkey" in the minds of quite a number of people; whether the baboons, mandrills, and macaques; whether the little South American monkeys of the Italian organ grinder; or whether all of these primates are monkeys, makes little difference in this consideration. Animals *not very widely different* from them—from the layman's viewpoint—have undoubtedly had their place at one time or another in our ancestry, depending on how far back in time we proceed.

Were it possible for us to go back a few million years and actually see our mid-Tertiary Period ancestors, we should find no better, no more descriptive, popular term for this "common stem" than ape or monkey. We might maneuver around the use of the objectionable word by some more scientific term; but the fact would still remain that our ancestral animal had many of the charactersitics of the monkeys and anthropoid apes of our times.

Let us then be frank and not designate our ancestor by some misleading phrase if we mean thereby to give the impression that the "common parent stem" was a much more noble creature than the living apes and quite different from them. . . .
The fact of man's descent *through* several monkey-like forms seems inescapable. . . .

Of this too reassuring pronouncement [of the California committee, cited by me above], *Nature*, the well-known English scientific journal, rightly says, "It is significant of the strength of the anti-evolutionary movement in the United States that this committee, the chairman of which is president of the University of California, should endeavor to appease public opinion by its approval of such a misleading assertion, which suggests that the members of the committee are in favor of teaching only a diluted Darwinism."

The Scientific American agrees with *Nature* that the statement in question is misleading; though we do not believe that the California committee, composed chiefly of scientists in other than the biologic sciences, intended to mislead. The misleading statement has, in fact, been made so frequently and by so many writers that belief in it has become almost fixed.

CHAPTER V

LESSON FROM JOHN DANIEL'S FOOT

IT has frequently been stated that man has but three exclusively human muscles, all of the rest being shared with his cousins the man-like apes. These specifically human muscles are mostly concerned with man's erect posture and "the specialized character of the human foot" (Lull). But Dr. Dudley J. Morton, formerly of Yale and now of the American Museum of Natural History, recently discovered in the feet of two gorillas a small muscle which had previously been regarded as exclusively human.

When the gorilla known as "John Daniel" died, his body was donated by the Ringling Brothers to the American Museum. The body was dissected and distributed to various experts for intensive study. The feet were sent to Dr. Morton, a distinguished orthopedic surgeon. He has spent many years studying human feet and correcting their weaknesses.

One of the chief objections brought against the theory that man is descended directly from an ape-like ancestor was that even the most human-like of existing apes has a foot like a human hand, with opposable great toe. While the gorilla foot was recognized as nearest in form to the foot of man, it was admittedly more like man's hand, in some respects, than like man's foot; and it was not possible to prove that such a foot could have evolved into the type possessed by *Genus homo*. Recourse was therefore had to the theory that man's descent is not from any of the higher apes but from some more ancient primitive form, nearer to the lemur-like types. Darwin was of the opinion that "some ancient member of the anthropomorphous sub-group (i. e., of the anthropoid ape stock) gave birth to man. This view has been supported by Haeckel, Huxley, Gregory, Keith, Prof. Max Schlosser of Munich, and the majority of anthropologists and anatomists.

Dr. Morton's study of the feet of John Daniel I settled, for most authorities, all doubts on this question. He found that the foot of this domesticated ape was rapidly developing into the human form even within his short lifetime. To this important discovery was added that of Professor Huntington, of the College of Physicians and Surgeons (New York), that John Daniel possessed a certain muscle moving the outside of the foot, which was heretofore believed to be entirely absent in the feet of all apes. We now know that the *chimpanzee* foot does not differ materially from the foot of the inferior apes, while the foot of the orang and of the gibbon are more highly specialized for arboreal life, though the chimpanzee foot is the most generalized and therefore nearest in structure to the original arboreal anthropoid form. It might have de-

veloped into the gorilloid type had the chimpanzee not clung so closely to its tree-living habits. The gorilla alone possesses feet (including a well-developed heel) adapted to the upright carriage and ground life. The use of the feet when on the ground is essentially the same in both man and gorilla. Says Dr. Morton:

As a result of ground habits supplanting those of its early tree life an untwisting of the metatarsal bones (between the instep and toes) occurs, which carries the sole of the great toe toward the same plane as the other toes, as in man. The big toe bone untwists one way and the other toes the opposite way. The skeleton of the human foot still shows a slight degree of the same twisting as the ape foot. The foot of "John Daniel" showed the untwisting process at an unusually early age because, as a captive, he had been deprived of his natural tree life. . . .

In man's foot I have found that there is an appreciable amount of the twisting toward the big toe in the first and second toes, as in all the apes.

It is most significant that so great a change in a tree-climbing foot toward a ground-walking foot should be accomplished within the life-span of the gorilla. While the big toe does not reach the stage of being simply divergent without twisting, as in man, nevertheless the process only lacks time to fulfil such a condition, or the stimulus of a suitable change in the environment, or in the character (psychic or otherwise) of the species.

A very important result of my examination of "John Daniel's" foot was that when the gorilla foot is used on the ground the toes rapidly approximate the relative proportions of the human toes, instead of resembling the proportions of the human fingers, as in other apes. On viewing a baby gorilla foot one is immediately struck with the comparative shortness of the big toe and the extra length of the third toe. However, in the adult gorilla the greatest growth was in the second toe; in the third it is much less, but distinctly more than in the big toe. Incidentally the proportionate growth of the second to the three outer toes points clearly to a tendency toward reduction in the outer toes even in the wild gorilla, conforming more closely to the human arrangement.

Young "John Daniel," who as a captive had been deprived of his early tree-climbing life and the influence that life would have had upon the development of his feet, and who had been restricted to the use of his feet on the ground, showed the highest percentage of growth in the big toe, which is much greater than that of the second toe. Comparison of the relative growth of these two toes showed almost startling disparity in growth, which can only be laid to the early alteration in life habits in the younger animal. "John Daniel's" big toe since his capture had grown 32%, his second toe 26%, while the adult gorilla's big toe had grown since the age of two 77% and his second toe 96%.

If the rate of growth of "John Daniel's" toes had been continued to the age of a wild adult gorilla, they would have been very different from that animal's and would have approximated human proportions. That proves clearly that an animal like this could have been our ancestor.

Dr. G. S. Miller, of the United States National Museum, Washington, has stated the objections to a transformation of the gorilloid toe to the human type in a paper on "The Conflicting Views on the Problems of Man's Ancestry," as follows:

1. Opposability of the great toe to the sole, which is found in the gorilla and is lacking in man.

2. Difference in the joint between the inner cuneiform (instep) and the first metatarsal bone (bone between the instep and the toes).

3. Difference in the comparative lengths of the respective toes in the gorilla and man.

Dr. Miller's view of man's origin is this: "The distinctively human line branches off from the primate stock at a point near that at which the line leading to the gorilla and chimpanzee originated and at a time when the great toe had not lost its simple divergent character." But Dr. Morton, in discussing various theories concerning the origin of man, remarks:

The probability of "parallel evolutionary progress" between man and the anthropoids is far from satisfying after the evidence is carefully weighed. As Dr. Miller indicates, all the evidence points strongly to a union of the two groups, but because any method has heretofore been inconceivable whereby the opposable great toe of the ape would be transformed to a human position, the evidence which would connect the union between the two families has been overruled by some and the possibility of this remarkable parallel development has been sustained.

He says further:

We have now to consider the opposability of the great toe as found in the apes. If you will examine your hand you will find that the surface of the thumb is at a right angle to that of the fingers and that as you turn your thumb in, it rotates until its surface comes against the palm. In the ape foot the big toe when at rest is at a right angle to the sole, and can be moved toward the sole like the human thumb, but it does not come completely against the sole of the foot.

My examination of the feet of "John Daniel" and the other primates showed that the great toe of the ape turns toward the sole of the foot because of a twisting of the shafts of the bones of the foot that hold the toes. "John Daniel," who had been deprived of his normal tree life for a period of about four years, showed some interesting differences from other apes—the twisting of the toes toward the thumbs was greatly reduced. In other words, he was already developing the human type of foot.

In the adult gorilla, after it has been forced by its weight to take to ground life, a similar change is noted. The surface of the big toe and the other toes, which originally formed a right angle, show a marked widening and definitely approach the common plane characteristic of the human foot. There still remains the original ability to move the great toe in and out, but opposability, as displayed by the other apes, is modified. [See Morton, D. J., "Evolution of the Human Foot," Part 1, *Amer. Jour. Phys. Anthrop.*, 1922, vol. V, No. 4; *ibid.* 1924, vol. VII, No. 1.]

Utterly rejecting Osborn's Oligocene Dawn Man, and insisting on the close relationship of the human family with the chimpanzee-gorilla stock, Gregory, writing in *The Quarterly Review of Biology* (December, 1927, asks:

About how many generations may have existed since the final separation of man from the anthropoid stock, that is, since interbreeding between the two ceased? Assuming that this occurred in the Middle Miocene, that would give a period of about ten million years to the Upper Pliocene *Eoanthropus*. The anthropoids approach sexual maturity at ten years of age, while certain races of men can breed at twelve years. Assuming twelve years, or about eight generations to a century, as the average rate, that would give 800,000 generations as the transitional period between *Dryopithecus* and the Piltdown Man.

Dr. Gerrit S. Miller once said that if the divergent great toe of a chimpanzee were to be pressed around so as to be parallel with the other toes, it would cause the animal intense pain and that he would therefore not walk in such a way as to produce such pressure. Hence a chimpanzee-like foot could never be changed

into a human foot. But even an acute pain, divided among 800,000 generations, might be supportable. In other words, much might be done toward bridging the remaining gap between some member of the *Dryopithecus* group and man during 800,000 generations, especially in view of the relatively high structural variability of all the known races of man and of anthropoid apes

In the current (1929) issue of the annual report of the Smithsonian Institution, according to a *United Press* dispatch (Nov. 23), Mr. Gerrit Smith Miller, Jr., curator of mammals, since 1909, of the U. S. National Museum, is quoted as saying that the *Pithecanthropus* and Piltdown ape-like man fossils "are too incomplete to be regarded with certainty as having pertained to creatures intermediate between man and some kind of ape." As this book goes to press, my copy of this annual report has not yet arrived. Hence the only reply which I can make is, that if Mr. Miller said what he is reported as saying in his recent article, it sounds more like the Rev. W. B. Riley or Billy Sunday than like the statement of a student of anthropology—or even of mammals.

CHAPTER VI

THE TEETH OF APES AND MEN

A VERY interesting and significant fact was revealed by the comprehensive studies of Dr. Milo Hellman, research associate in the department of anthropology in the American Museum of Natural History, and Dr. Gregory. These experts studied a series of first and second molars and first premolars of men and apes, living and fossil. It was found that the dental pattern found in existing primitive races and in fossilized early man is much nearer that of the fossil ape *Dryopithecus* than is the civilized modern's. The pattern of dental construction is fundamentally similar in all the forms examined from the ancient stem form to its modern descendant's. While modern savages approach more closely in brain development to modern civilized men than they do to their ape ancestors, their teeth patterns are nearer to the ape ancestor's patterns.

The normal human dentition contains the same number of teeth, 32, as that of the other *Catharini,* so that, as Lull remarks, "the reduction from the original 44 is a *primate* and not a *human* characteristic." In all the Old World apes the dental formula is the same as in man:

$$\frac{2}{2}\ \frac{1}{1}\ \frac{2}{2}\ \frac{3}{3}$$

i2, c1, p2, m3 × 2=32.

So that there are, as a rule, in both man and the anthropoids, in either side of the upper jaw, two incisors, one canine, two premolars, and three molars; and on either side of the lower jaw, two incisors, one canine, two premolars, and three molars.

It should be added that in both apes and man there first appears a set of milk teeth numbering 20 in all, and with a similar arrangement. It can, one would think, scarcely be a mere coincidence, "parallelism," or "convergence," that these particular numbers and arrangements of the milk and adult teeth are found only in man and the Old World monkeys and the anthropoid apes. In no other groups of mammals is such a dental formula to be found, and it is undoubtedly to be accounted for by inheritance from some ancient ancestral anthropoid stock, as suggested by Darwin.

In a popular contribution to the monthly magazine *Evolution* (December, 1927), Dr. Gregory set forth some facts which are quite pertinent to the present study, and which therefore I repeat here:

> How many principal points or cusps has the reader got on his second right or left lower molar? If he is like most people he will find only four cusps, separated from each other at their bases by two main grooves forming a cross. This

is a distinctly human arrangement and taken by itself is a conspicuous point of difference from the corresponding tooth of all the known apes, living and fossil, which have normally five cusps on the second lower molar.

But about one fourth of white people have a fifth cusp on the first lower molar and a good many Negroes, black Australians, and other primitive individuals have five cusps on all three lower molars. And as there are hundreds of jaws in which the fifth or hinder cusp has almost disappeared, so there are other jaws in which it is less and less reduced. In the most ancient fossil human jaws known, namely the Heidelberg jaw, the Mousterian jaw, and the Ehringsdorf jaw, there are five main cusps on all three lower molars.

Is it another coincidence that each of the three lower molars of all the known anthropoid apes also bear five main cusps? And is it also by chance that in all known apes and many men these cusps are separated at their bases by six main grooves, each of which obviously corresponds in position in apes and men? Thus if the reader wears the sign of the cross on his second lower molar, the chances are that his first lower molar is impressed with the mark of the ape, and certain it is that the oldest known fossil human lower molars are the ones that most closely approach the "*Dryopithecus* pattern" of the primitive ape molar.

CHAPTER VII

CHARACTERS COMMON TO APES AND MEN

MAN shares with the apes a marked tendency to *variation*, not only in dentition but in other features, skeletal and muscular —and, one may add, psychical. All anthropoids and man are what Gregory calls "highly mutable and subject to evolutionary change" (*Scientific American*, p. 232, September, 1927). Obviously, and naturally, there are many differences between man and modern apes, and marked differences among the apes themselves. But, as first pointed out by Huxley ("Man's Place in Nature," 1863), "the differences between man and the great apes are not so great as are those between the man-like apes and the lower monkeys."

Sir Arthur Keith has clearly shown, for example, that the maternal organs of the gibbon, which has adopted an habitually upright posture, are far nearer to man than to the lowest of the primates. If the student of today studies the structure of man's body, says Keith, "he finds it framed on the mammalian plan, and if he compares it with that of anthropoid apes he finds the points of resemblance to be so numerous and so close that he cannot think that such a degree of resemblance could be a result of mere chance." Or, as Lull states, "bone for bone, the comparison can be made, and it will be found that the differences are vastly less striking than are the likenesses."

The skull of man and the apes consists of the same 20 bones, "seven of which constitute the spacious case which encloses the brain, the other 13 bones forming the facial skull." Haeckel remarked that in man and the gorilla and chimpanzee the same 200 bones, in the same order and of the same structure, are moved by the same 300 muscles—which is substantially correct. The famous anatomist Robert Hartmann demonstrated completely, long ago, that whatever organ be taken for comparison, the anatomical difference between the lower Old World monkeys and the most highly developed anthropid apes is far greater in every respect than the difference between the latter and man. (Hartmann's great work, "The Anthropoid Apes," was translated in the International Science Series in 1872). Haeckel regards the fact established by the late Dr. Emil Selenka (*Menschenaffen; Studien über Entwickelung und Schädelbau*, 1898-1906) that the anthropoid apes share with man the peculiar structure of the discoid placenta, the *decidua reflexa* (a portion of the membraneous lining of the uterus), and the pedicle of the allantois, as having great significance. Could it happen by "parallelism" that the process of supplying the unborn child with nourishment is exactly the same in man as in the anthropoids, and in no other mammals, including "monkeys"?

Keith tells us that as early as a million and a half years ago (very conservatively estimated) certain apes had 170 structural characters in

common with man; and the later chimpanzee-like apes, whose fossil remains have been found in various parts of Europe and India (Siwalik Hills, north of the Indian desert) had developed 300 such structures. At the present time, man has 396 characters in common with the chimpanzee, 385 with the gorilla, 272 with the orang-outan, and 188 with the gibbon.

Apes, like men, vary considerably in the matter of hairiness. A human being at one stage of his foetal development may have more hair on his back per square centimeter than is found on an equal area on the back of a young chimpanzee or a gibbon, as witness the figures below.

The number of hairs found on a square centimeter of the skin was counted on a very young infant (embryo, about six months), and also for the young monkeys and apes given herewith:

	Man	Orang	Chimpanzee	Gibbon	Macacus
No. of hairs on a sq. cm. of the head	880	383	400	546	1240
No. of hairs on a sq. cm. of the back	686	937	420	440	1406

(Quoted from Meyer Leirheim, *Zeitschrift für Anatomie und Anthropologie,* 1912, by G. F. Scott Elliot, "Prehistoric Man and His Story," London, 1915.)

Man and the orang have twelve pairs of ribs, the gorilla and the gibbon thirteen, and the chimpanzee fourteen. While the orang has the same number of ribs as man, he has four lumbars to man's five. Occasionally a human being is born with thirteen pairs of ribs, though the additional pair is but feebly developed. The tail vertebrae (caudals) which coalesce to form the coccygeal bone (coccyx) number three in the gibbon, four in man (as a rule), and five in the gorilla, chimpanzee, and orang. In both man and the apes a tail is present during foetal development, with muscles for wagging it. Human beings sometimes come into the world with a tail, and, rarely, with power to wag it.

Each family of apes has, during the long course of its evolution (and adaptation to environment), come by anatomical features which are peculiar to itself. Keith found that a full analysis of the structural details of man's body shows about 30% of them which are peculiar to himself. The gorilla and the gibbon each have about 16% of features peculiar to their own family (Keith, *Rivista di Antropologia,* Vol. 20, p. 1, 1916). He cites as examples of man's peculiar characters his nude skin, his projecting nose with well-marked wings, the size of his brain, the strength of his thigh, the form of his leg, the shape of his foot.

As examples of characters common to man, the gorilla, and the chimpanzee, he cites the air-chambers which branch off from the nasal cavity. These, he states, have the same arrangement and are of the same number in these three families. Another example is to be found in the small bones of the wrist. Of the higher primates, only in these three has the *os centrale* disappeared as a separate unit from the carpus; yet, in a foetal stage, this bone is present in all three; and as a separate element in adults of all the other primates. Usually the "central" incorporates with the scaphoid bone, but sometimes it fails to coalesce. Curiously enough, man shares with the orang, and with the orang only,

but five per cent of his structural detail. On the other hand, says Keith, man shares with the gibbon eight per cent of structural features which are not to be seen in the bodies of the great anthropoids. There still persists in man a small residue of anatomical details which are a heritage from the tarsioid or lemuroid ancestry.

From the details revealed by anatomical analysis it is plain that evolution has not proceeded in an orderly or simple manner in shaping the bodies of the higher primates; characters are curiously scattered. Yet to explain the distribution of characters in the various families we must suppose that man's ancestry is linked closely to that of the African anthropoids—the gorilla and chimpanzee. In some instances we obtain help in explaining the distribution of characters by calling in the aid of *collateral* or parallel evolution; in other cases Mendel's discoveries in heredity assist us; further, we see that the body of man and of ape is a great mosaic work of structural elements and that progressive changes may occur in one set of units while retrograde changes affect another set.

(See Keith's splendid article, "Man, Evolution of," in the thirteenth edition of the Encyclopaedia Britannica, from which the above paragraph is quoted.)

In a recent address before the Royal Academy (London), Dr. Arthur Thomson, professor of anatomy at Oxford University since 1893, told his audience: "It is only conceit which makes mankind believe it is not descended from the ape. Although generations have brought great changes in anatomy, the similarities are too great to be ignored. A baby, until it can walk, resembles the ape in nearly every respect."

As Darwin long ago stated, notwithstanding his noble qualities, his "god-like intellect," man "still bears in his bodily frame the indelible stamp of his lowly origin."

CHAPTER VIII

SIMIAN MENTALITY

WHILE a number of excellent books have appeared during the past five years or so on the psychology or mental states of the anthropoid apes (including especially the results of the researches of Kohler and Yerkes), it remained for Prof. Frederick Tilney, of Columbia University, to give to the world a really complete account of "The Brain from Ape to Man"—a truly monumental work in two volumes, totaling 1,120 pages, costing $25, and the rich fruit of fifteen years of very painstaking research. Huxley, in his famous "Man's Place in Nature," did not minimize the vast hiatus that exists between the brain of a human being and that of an anthropoid ape. But he emphasized the fact that this difference in structure and proportions was mostly quantitative, that man's brain contains no fundamental structure not shared with his cousins the great apes.

Dr. Tilney—unfortunately, as I see it—follows Osborn in separating man rather widely from the existing man-like apes. But it is not anywhere shown in his two heavy volumes on just what sound foundation this concept rests. Quite sufficient facts have already been adduced even in this little volume, one would think, to show that man's direct kinship with the chimpanzee and the gorilla is simply unmistakable. But the evidence will be still further multiplied as we proceed in this study.

Prof. C. Judson Herrick of the University of Chicago—a highly competent witness—finds Dr. Tilney's volumes "a curious mixture of generalities about habits and probable ancestry of lemurs, monkeys, apes, and men, apparently intended for general readers, and long technical neurological descriptions which can be read only by experts." He goes on (in a review in *The New Republic,* September 10, 1928):

> In fact, the book is rather hard reading on both sides. The neurologist finds it unsatisfactory for lack of sufficient precision in description, and the more popular passages are marred by a fondness for highbrow technical words when the meaning could be better expressed in very simple language. . . .
>
> When we do get the meat out of these long technical descriptions, there is left no room for doubt that the big and interesting brutes that we call apes and the weaker but more intriguing bipeds that we call men are generally related. And their brains alone will give the key to the mysteries of human origin, for the only significant difference which separates man from brutes lies in his brain and what he does with it.
>
> The organs here described are mechanisms of behavior, just as are bones and lungs and muscles. And they are organs of the more complicated features of behavior; they are the organs which mark the difference between meager and inefficient life and wealth of experience and competence in getting the most pos-

sible out of life. In mankind they include the apparatus "which acts as the accumulator of experience, the director of behavior, and the instigator of progress." . . .

If we think with our brains—and if we don't, how do we do it?—then the brain is a thinking machine in just the same biological sense that the heart is a pumping machine. The biological evidence is clear-cut on this point. But the thinking machine in just the same biological sense that the heart is a pumping machine. The biological evidence is clear-cut on this point. But the thinking machine and the pumping machine are differently constructed, and so, of course, they deliver different kinds of products.

Natural science is mechanistic. If human biology is to rank as a natural science it must, accordingly, develop along one of two lines. It may follow the old traditions and leave mentality out, because mental acts are supposed to be non mechanistic and hence inaccessible by the naturalist's methods; but this leaves out of human biology most of the things that make humanity interesting and worth while to us. The other alternative is to revise our ideas of natural machines and to enlarge this notion to embrace living mechanisms that grow and reproduce and feel and think.

This may not be so absurd as it sounds, and in fact, it seems to be the only way open to us if we are ever to hope for fruitful application of scientific methods to the acute problems of human life and conduct. A lot of popular and philosophical mysticism and metaphysical prejudice about disembodied spirits that can make something out of nothing may have to go into the discard before we can find a really scientific approach to the natural history of human nature—the whole of it, and not merely the parts of us that we share with brutes.

Despite the obvious defects of Dr. Tilney's book, the fact remains that it furnishes the student of evolution with a wealth of valuable illustrations, including a description of the external and internal anatomy of the brains of the various families of Primates, from the smooth-brained marmoset, on through the ascending stages of the evolution of the brain down to the Cro-Magnon artists of some 20,000 years ago, with additional speculations on "Man—Past, Present and Future."

Just why a discussion of the very important fossil child-ape *Australopithecus* (the Taungs skull) is omitted it is difficult to "figure out," since much authentic information has been available for several years past—an omission that does not occur in the present volume.

Dr. Tilney's studies show conclusively that there has been "a definite increase in the width of the brain, expanding those areas which have to do with the higher faculties of reason and judgment." However, there is nothing new in this statement; but the many careful observations and measurements made by Dr. Tilney serve to reinforce a conclusion arrived at by other investigators from less nearly complete data. "The human brain," says Tilney, "from its most humble beginning has manifested advances to specialization of those areas associated with the production of spoken language, with the regulation of highly skilled acts, and most probably at least with understanding."

Professor Tilney considers right-handedness an index to human progress. The anthropoids and man possess what might justly be called a right-handed brain. Left-handedness is inherited, not merely a chance acquisition. Experiments conducted at the New York Zoological Park with orang-outans show that although these apes are more or less ambidextrous, nevertheless, when they wish to make an exceptional effort

they use the right hand in preference to the left. However, left-handedness may occur as an exceptional variation. Prof. G. Elliott Smith, of University College, London, discovered a fossil human skull that bore clear evidence of having belonged to a left-handed woman. In a communication to the British Medical Journal (London), in 1926, Professor Smith pointed out the definite evidence, provided by the skull, of the reversal of the normal symmetry of the brain-case, and the reasons for associating this reversal with left-handedness. To use his own words:

In the winter of 1907-08 Prof. Wood Jones and I investigated the significance of this reversal, accepting as the criterion of right- or left-handedness, respectively, the observation whether the right or the left humerus was the longer and stronger. In the cranium I found that the impressions upon the bone were reversed in those cases where the left humerus was longer and more robust than the right.

The objection has been raised by several critics as to the validity of these inferences from the size of the humeri as indications of right- or left-handedness. Since 1845, when Arnold raised this problem for consideration, an extensive literature has accumulated from repeated discussions. An admirable summary by the late Professor Gaupp was published at Jena in 1909. He summarizes the researches on the question of the excess in length of the left or right arm, and shows that these differences are usually associated with left- and right-handedness respectively. However, he calls attention to the fact that at the time of birth the length of the bones in the two arms is identical. Occasionally it happens (in people whose occupation compels them to exercise the left arm more than the right) that a person with a congenital tendency to right-handedness may have longer and stronger bones in the left arm. This is altogether exceptional, and should not be allowed to discredit the clear inference from a large mass of evidence that the length of the arm-bone in the great majority of cases is a safe indication of right or left-handedness.

During the course of his work in Nubia in 1907 Prof. Wood Jones attempted to correlate his observations on the skeletons of the ancient inhabitants of Nubia with the conditions found in living Egyptians, and he discovered that in right-handed living people the left clavicle was longer and thinner than the right. Then, proceeding to examine the bones in the skeletons, he found in those cases where the right humerus was longer and stronger than the left that the left clavicle was longer and thinner than the right. Moreover, he found that when the condition was reversed the left humerus was then the bigger bone. He regarded this as a confirmation of the use we had made of the humerus as an indication of right- or left-handedness.

The asymmetry of the brain associated with this asymmetry of the limbs is not restricted to modern man. It is characteristic of the human family as a whole, and it seems to be one of the distinctively human traits revealed in most of the known fossil material. The asymmetry of the brain is as old as the human family itself, and is a fundamental character distinguishing man from all other members of the order Primates.

Attempts have been made in the past to determine whether extinct members of the human family were right- or left-handed, by a study of the implements made by these people. But so far as I am aware no one has attempted to solve this problem directly by a consideration of the fossil remains of man himself. The evidence of asymmetry of the brain to which I have called attention throws a light on this problem that is much more reliable than any inference which can be made from man's handiwork.

The question naturally suggests itself whether there is any trace of asymmetry in the anthropoid apes. Although the two cerebral hemispheres in the apes are approximately symmetrical, some interesting facts suggest the remarkable conclusion that the bones of the right arm are longer than those of the left arm in

the gibbons and orangs (as in man), but the bones of the left arm are the longer in the chimpanzees and gorillas. Though there is no obvious asymmetry of the brain, there seems to be in the anthropoid apes an instability that affects the symmetry of the limbs, although neither the right nor the left is so definitely selected as in the case of the vast majority of human beings.

It is of some interest to note that B. S. Parson, in his book "Left-handedness" (1924), came to the conclusion that the ocular dominance—that is, the use of one eye for fixation—determines both cerebral dominance and the "handedness" of the individual.

In all these discussions it must be remembered that even if the right- or left-handedness does not make its appearance until well on in the first year of life, it is due to congenital tendencies that manifest themselves at this relatively late time. It must also be remembered that these congenital tendencies may in many cases be overcome to a considerable extent by training; so that it is possible to get a brain showing the asymmetry distinctive of left-handedness with limbs which show the conditions usually associated with right-handedness.

The investigation of Prof. Catherine Beers, of the University of Southern California, showed that about 12% of persons are left-handed.

The brain naturally grew, symmetrically or asymetrically, other things being equal, as the needs of our ancestors evidenced variety and the necessity for what Spencer called "correspondence with a wider environment." Meanwhile, the motor mechanism of the body as a whole kept improving. The more the brain was worked, as Dr. George A. Dorsey points out ("The Nature of Man," p. 70, 1927), the better it developed:

Its area of association between hearing and seeing, seeing and touching, etc., kept on growing. These areas are the distinguishing features of man's brain. If man had received no more than mere bodily form from his monkey ancestor, he might as well have had an opossum for an ancestor. It was not mere body that made monkeys smart; nor their brain that produced their hand. Their brain made the most of their hand, but, as Jones says, while man can play the violin because he has a big brain, what could his brain do if his hand were a horse's foot?

Again (to quote the same author):

Apes can communicate information to one another—how well can be learned from the pages of Dr. Wolfgang Kohler's valuable book, "The Mentality of Apes." But the information is all emotional—dangers, foes, enemies, friends, food, screams of rage, distress, and abject fear, whines of teasing, scolding, and petulance, and the soothing, cooing, billing, of affection and love. Within their repertoire of emotional cries, ranging from the passion of love to that of rage, they are marvelously clever at performance and in understanding. But not one single *word* as a *symbol* or a *sign* for a concrete object, or act, or relation. Just why they do not talk no one knows. Perhaps adequate stimulus to learn to talk has not yet been offered to them. At any rate, it is known that a chimpanzee or a gorilla could not learn to speak enough words to pass a simple "intelligence" test, especially as nobody knows anything about intelligence. . . .

With the development of speech as a means of communication, and especially as a definite tool for naming objects, human social behavior entered upon a quite new career, the end of which is not in sight. Language was the turning point in man's break from the apes; its origin was from such vocalizations as apes and monkeys make.

A few words only need be said here respecting the comparative size of the brains of man and the apes. In a normally developed adult

European male the capacity of the cranial cavity, which represents the size of the brain, is 1,500 cubic centimeters. The average male gorilla has a cranial capacity of 470 c.c., though in a few exceptional cases it reaches a capacity nearer 600 c. c. The average male orang has a brain capacity of 412 c.c., and the average male chimpanzee of 390 c.c. Although the human brain is so much larger than that found in apes, their principal form is substantially the same, even in details of structure. Naturally, the convolutions and fissures bear the same anatomical names, and their physiological action is identical.

A few years ago, Dr. W. W. Keen, the famous Philadelphia surgeon, was invited to deliver the principal commencement address at Crozer Theological Seminary, at Chester, Pennsylvania, and he selected for his subject the "controversial" theme, "Surgical and Anatomical Evidences of Evolution." As a surgeon, Dr. Keen had had occasion to make a close study of the brains of the lower animals and man. He told his audience some of his experiences, appealing directly to facts, not to "mere theories." He remarked that there is in the brain of man, and also in that of "the lower animals," a deep furrow running obliquely downward and forward above the ear, called the "fissure of Rolando." Grouped around this, as has been shown by experiments with animal brains, are a number of aggregations of nerve cells in the gray matter of the brain, which are known as "motor centers." If one of these is stimulated, by an electric current, it produces motion in some definite part of the body, and nowhere else. There is such a center for the arm, one for the leg, for the face, the fingers, and so on. These centers have been exactly mapped out in the animal brain, and it has been found that "in the human brain the location of the corresponding motor centers is a duplicate of those in the brains of animals."

Dr. Keen had as a patient a young woman suffering from epilepsy. She told him that the attacks always began in her left thumb, then spread to the hand and the arm, with convulsions and unconsciousness ensuing. Since the human thumb corresponds with the great toe of the forefoot of animals, Dr. Keen opened the patient's skull over a point agreeing with the location of the great toe motor center in the animal brain, and cut out a little cube of brain substance. There are no fewer than nine muscles moving the thumb; but so exactly had the excision of the proper motor center been made that every one of these nine muscles was paralyzed and not another muscle of any kind was affected. The epileptic attacks, from daily occurrence, diminished to about one a year, and in a few months the patient even regained full control over her thumb.

Another case given by Dr. Keen was that of a midshipman at Annapolis who was injured in a football game. His skull was not fractured, but soon after the accident he developed local convulsions, first in the right leg and later and chiefly in the right arm. The only evidence of a local injury was a slight bruise at the outer end of the left eyebrow. Dr. Keen remarked:

> Had I seen this case prior to 1885—when I first made a careful study of the motor centers in the brain—I should, of course, have followed only the visible indication of the location of the injury to the brain, namely, the bruise. Had I

opened his skull near the bruise I should have been confronted with a perfectly normal brain. I should then have been compelled to close the wound and have, perforce, done nothing more. He would have died within two or three days.

But experiments on animals after 1885 had shown that above the ear and a little in front of it lay the centers controlling the muscles of the face, the arm, and the leg from below upward, the leg center being near the top of the head. As there was no fracture of the skull and as the convulsions began first in the leg and then concentrated chiefly in the arm, but never extended to the face, my diagnosis was a rupture of the large artery on the surface of the brain over these motor centers; that the escaping blood had formed a clot, the edge of which first overlapped the leg center, but that the chief mass lay over the arm center. I felt sure that it had not yet reached downwards over the motor center controlling the muscles of the face. Evidently the clot must be immediately removed or he would quickly die.

Operation showed that the diagnosis was correct. The skull was opened, and the clot was found placed exactly as Dr. Keen had predicted. Recovery was uninterrupted, and the patient re-entered the navy in perfect health. The exact similarity of motor centers in the brains of man and the lower animals was proved.

For a number of years now, genetic psychologists have attempted to teach the chimpanzee or the orang to speak. The results have been all but negative, as in the case of Köhler's chimpanzees. But no one knows why. The fault does not lie with the mouth parts of the ape, which are similar to those of man. His anatomical apparatus is quite equal to the task. With a dog the conditions are very different. Yet I once heard a dog speak a few words in German, giving his own name when asked to do so. Dorsey, opines that apes do not talk for the simple reason that they have nothing to say. By infinite patience, Furness taught his young orang to say "Papa," and it may be that the ape learned that this sound was in some way related to her master. Furness believes that she knew it was his name. The same ape was also taught, by repeated practice, to say "cup." However, there is no strong evidence to show that the word uttered meant anything to her. She loved her master; he wanted her to say "cup" and "Papa," and she "aimed to please." It is, however, quite possible that she knew what she was talking about. (See William H. Furness, "Observations on the Mentality of Chimpanzees and Orang-outans," *Proceedings* of the American Philosophical Society, 1916, *55*, pp. 281-290; also Robert M. Yerkes and Blache W. Learned, "Chimpanzee Intelligence and Its Vocal Expressions," 1925).

Boutan, working on the rather vocal gibbon (said by Bölsche to be able to utter musical sounds) found that this ape was capable of speaking no real words, but mere emotional utterances. (See Louis Boutan, *"Le pseudo-langage," Actes de la Societé Linneane de Bordeaux*, 1913, *67*, pp. 5-80).

Furness states that the orang and chimpanzee evinced a clear *comprehension* of the significance of words for objects and actions, and that his apes were able to understand what was said to them better than any professionally trained animals he had ever seen. Miss Learned recorded in musical notation the various vocalizations of two young

chimpanzees, seeking at the same time to discover the significance of the sounds; and Yerkes undertook by simple experimental procedures to train one of the animals to reproduce sounds in association with objects. The results of this instructional attempt were almost wholly negative and they convinced the investigator of the slight tendency in this ape to reproduce auditory stimuli or to imitate sounds produced by its kind or by man. (See "Anthropoid Behavior," by Robert M. Yerkes and Margaret Sykes Child, *The Quarterly Review of Biology,* March, 1927, pp. 37-57). Yerkes is inclined to think that the great apes "have plenty to talk about, but no gift for the use of sounds to represent individual, as contrasted with racial, feelings or ideas."

It is possible that their disinclination for talk had a survival value in their native habitat. When danger is imminent they can all make noise enough—warning cries. Mere talk, under ordinary circumstances, might have attracted the attention of enemies. However, our authors say, "We may not safely assume that they have nothing but feelings to express, or even that their word-like sounds always lack ideational meaning," for they certainly appear to "have ideas, and may on occasion act with insight." Certainly the late Professor Garner, who spent years in a cage in the midst of wild chimpanzees, insisted that they had words and claimed to understand many of them.

In his well known book, "Arboreal Man," Prof. F. Wood Jones points out the psychological—one might almost say cultural—value of living in trees, as did our simian ancestors. This mode of life, when not continued beyond a certain point, not only made it possible for them to evolve into human beings after their descent to the plains, saving them from becoming quadrupeds, but developed their brains—or at least put a premium on brains—and their social instincts. In the branches of the trees, with their crude nests, arose "the family," and we meet with a further development of that important factor, first popularized by John Fiske, "the prolongation of infancy," with all that this implies for simian and human development. But all goes back in the long run to the ape's power to grasp and closely inspect objects with "hands"—for man's arm cannot be used as a leg. Dr. Wood Jones says:

> The power to grasp with the hand and fingers seems such a very simple accomplishment that it is difficult to realize how such an apparently trivial beginning can have produced the tremendous changes that follow in its train. The power of the hand-grasp has made possible the forerunners of the Primates, has perfected the evolution of the Primates, and paved the way for the development of man. . . .
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> The arboreal habit conferred its benefits by emancipating the fore-limb from the duties of support and progression; and by differentiating its functions from that of the hind-limb, it saved the animal from becoming quadrupedal. In differentiating the functions of the two sets of limbs, the animal gains a great deal. Some animals, one might almost say, have gone too far in adapting themselves to the arboreal habit. An animal saved by the arboreal habit from becoming quadrupedal does not gain the maximum of the benefits derivable from its new mode of life if it is saved from this fate only to become quadrumanous. Four feet do not lead far in the struggle for mammalian supremacy, four hands do not lead a great deal farther. It was the differentiation into two hands and two feet that provided the great strength of the stock from which man arose. . . .
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> The human hand, a strangely, almost shockingly, primitive survival, has re-

ceived enormous praise mistakenly lavished by the philosopher and the anatomist; but the human foot, a wonderfully modified and distinctly human member, has had but scant appreciation. . . .

Zoologically speaking, we may say that the very useful and specialized foot adapted for terrestrial progression is a foot of few digits. It may, in fact, be a foot composed of a solitary digit. The evolutionary stages by which the horse has come to stand solely upon its third digit are well known. Similar processes produced the two-digited foot of the deer and of the ostrich. There can be no doubt that man is trusting, not to this third digit, but to his first, and that all the others are undergoing a process of comparative atrophy. This is in reality a most interesting problem. There is an admitted tendency to specialize one digit in a thoroughly adapted terrestrial foot. Man applied an arboreal foot to terrestrial progression, and in this arboreal foot the best-developed member was the old grasping digit—the first, or big toe. It seems that upon taking to a terrestrial life he has started the elaboration of this already specialized toe, and is tending toward the development of a foot which is quite unique—a foot in which the first digit is the dominant, and in the end, perhaps, the sole surviving member.

While the ape parents were eventually well provided with the means for self-protection and further advancement, the baby ape is quite as helpless as a human infant. Yerkes, in his absorbing book, "Almost Human" (1925), brings to light many heretofore doubtful statements and previously unknown facts concerning the life-history and "home life" of the anthropoids. Louis Montané, who made investigations in the Abreu primate colony in Havana, Cuba, where about 80 primates are being studied, had already written on the sex behavior and breeding of chimpanzees, and it was he who was first to report the birth and early behavior of Anumá, the first chimpanzee known to have been born *and reared* in the Western Hemisphere. He was ten years old in 1925, and may be still alive. In New York, W. Reid Blair, of the Zoological Park, reports that the young survive birth for only a short time; whereas in Berlin, G. J. von Allesch, of the Berlin Zoological Garden, had opportunity to study the behavior of mother and young over a period of weeks.

From these several contributions it appears that the period of gestation in the chimpanzee is not less than seven, nor more than nine, months. In this connection it may be stated that I have been informed of a (human) family in which all the children (four of them, if my memory serves me faithfully) were seven-month infants. If this is true —and I have no reason to doubt the veracity of my informant—then it might be considered a reversion to an ancestral condition. None of this family is renowned for intellectual achievement, so to speak. It is popularly believed that a seven-month baby has a better "life expectancy" than an eight-month infant; but modern medical science condemns this belief as a mere superstition.

While there is no exact record on the length of the period of gestation in any of the man-like apes, Dr. Carl G. Hartman, of the Carnegie Institution of Washington, has recently reported on the mating and parturition of *Macacus rhesus* (or Bhunder), a monkey very common over the center and north of India and in Further India, from the plains up to 10,000 feet in Kashmir. They are common in our zoological gardens, and are sometimes seen with organ-grinders.

Says Dr. Hartman (in *Science*, January 6, 1928):

For over a year the female in question had been found to menstruate regularly in cycles of 26 days. The successful mating took place from the ninth to the twelfth day after the beginning of the last menstrual period. . . . This is also about the time at which Corner (1923) and Allen (1927) had found ova in the Fallopian tube of the same species of monkey. For theoretical reasons, therefore, it is almost certain that conception took place within the three-day period when the female was left with the male. A male rhesus was born almost exactly six lunar months after conception.

All authorities agree that the new-born anthropoid is as helpless as a new-born human infant, and, as Yerkes puts it,

Without parental attention and assistance [it] would perish within a few hours. During the first few months of postnatal existence it is wholly dependent on the mother for nourishment, protection, and bodily care. Gradually it achieves independence through acquisition of the ability to walk, in which it is assisted by parental tuition, and is thus enabled to amuse itself in increasing measure, to seek food, and to develop steadily through play with others of its kind.

(A valuable contribution on "Sex Development in Apes," by Dr. Harold C. Bingham, was issued in 1929 from the Johns Hopkins University Press.)

This relatively extended period of infancy could not but be of the same educational and moral value to the chimpanzee and the gorilla families as it is seen to be in the case of humans. The late R. L. Garner, who claimed to have interpreted 44 chimpanzee "words" and who lived, as said, many years in the African jungle studying the great anthropoids at close range, contributed to our knowledge of gorilla *behavior* in his "Gorillas in Their Own Jungle" (Zoological Society *Bulletin*, New York, 1914, *17*, pp. 1102-1104). The conduct of gorilla children is little different from that of human beings. Prolongation of infancy, in their case as in ours, leads to development of the "home life".

We learn from Dr. Wolfgang Köhler, director of the Berlin Psychological Institute and of the Anthropological Station at Teneriffe, Canary Islands, that young chimpanzees enter into games with the same alacrity manifested by children in general. Often when a pair of his young chimpanzees began to stamp and circle around a post, others joined in the game, or dance, forming a ring, reminding one of a savage tribe in a dance. They seemed inclined to keep time together. (See Kohler, "The Mentality of Apes," 1925).

Speaking to an audience of civil engineering students of Johns Hopkins University, in a lecture tour of the United States in 1925, Dr. Kohler said:

My tests and years of study leave me no alternative but to assert that man is only a higher type of anthropoid, whose intelligence has undergone a great transformation through thousands of years of existence. . . . The ape cannot be taught mathematics; it does not understand words any better than a dog; but it has memory, inventiveness, and a high mental ability which stops short of aesthetics.

In an address before a section meeting of the New York Academy of Medicine (1928), Dr. W. Reid Blair suggested that man had over-

looked an opportunity for increasing his number of domestic and industrial servants. In commenting on Dr. Blair's suggestion, Dr. E. E. Free's *Week's Science* (New York) said:

> Even in its present state the chimpanzee is, Dr. Blair believes, the most intelligent of animals next to man. If primitive man had happened, he remarked, to select chimpanzees for domestication instead of dogs, if these clever and affectionate apes had enjoyed the long centuries of human companionship which has been the lot of the dog, it is impossible to say how greatly their intelligence might have been developed. Centuries of effort to breed the most intelligent varieties of apes, just as breeders have produced kinds of dogs for special purposes like running or hunting, would have added still further to the ape's mental powers. The brain of the chimpanzee is of much the same kind, Dr. Blair believes, as the brain of man, and the animal would probably profit greatly by human contacts. The fact that chimpanzees escaped human control and still remain free creatures of the forest may seem sentimentally admirable, but it was perhaps the ape's greatest misfortune, as well as one of man's.

The question has often been raised why all male chimpanzees and orangs become cross and intractable, even quite dangerous, after reaching full adulthood. A number of different answers have been given, but a solution offered by Dr. C. W. Beebe ("The Log of the Sun," pp. 468-469), seems to me to be the most satisfactory so far given. He believes it highly probale that the surly and morose disposition of the great apes incident to puberty is due to the increase in power of the jaws and jaw muscles. These developments react upon the skull, developing the median crest and at the same time thickening the cranial walls. There ensues, he thinks, a pressure upon the brain, with the consequent mental reaction. While it can neither be proved nor safely denied, the theory is sound, even if the emotional results noted are more largely due to other causes.

Professor Lull thinks that the confinement of anthropoids "may accentuate a tendency which would be less marked in a free animal. . . . But what it seems to point to is this, that . . . the simians, with the probably exception of the gibbon, have retrogressed from the relatively high estate of the common ancestors from which they and man have sprung, and while mankind has progressed onward and upward from the ancestral condition, his simian cousins have, due largely to force of circumstances, such as the retention of arboreal life and enervating tropical conditions, arrived at an inferior plane."

Want of space forbids that I dwell at any greater length on the mentality of the great apes. Of their "morals" I shall say nothing, excepting that many supposedly "human" traits are obviously inheritances from our simian ancestors, and that, on the other hand, many men and women show themselves capable of deeds of meanness and atrocity which would (figuratively speaking) bring the blush of shame to the hairy cheek of the most savage anthropoid known to science. On this phase of the subject, no better book has ever been published than Dr. William T. Hornaday's "The Minds and Manners of Wild Animals." Every phase of domestic as well as wild animal life is treated by this great authority, and in a most entertaining as well as authoritative way.

CHAPTER IX

AN AMERICAN ANTHROPOID?

IN THE issue of June 15, 1929, *The Illustrated London News* (a highly reliable journal) published a photograph of what appears to be an exceedingly man-like ape of a heretofore unknown genus, which would be, in itself, a remarkable event. But this creature is a New World anthropoid—a thing thought to have been non-existent either in North or South America. It was shot while attacking an exploring party in a thick jungle beside a river near the Venezuela-Colombia border, and has been given the name *Amer-Anthropoides Loysi,* after Francis deLoys, B.Sc., D.Sc., F.G.S., noted geologist, who shot and studied the specimen, a female ape about five feet two inches, and weighing about 115 pounds. The male was wounded but escaped into the dense forest.

The report of the discovery was communicated to the *Académie des Sciences* of Paris on March 11, 1929, and discussed by Dr. G. Montandon, to whom it was less of a surprise than to other scientists, for Montandon, of the French Anthropologic Institute, is an advocate of what he calls the Ologenic Theory, recently set forth by him in his *"L'Ologenèse Humaine"* (Paris). According to this theory, anthropoids as well as hominians (*genus Homo*) originated independently on the various continents. In this instance, *ex hypothese,* we are dealing with a case of "parallelism." This creature, "with strangely human figure, eyes, and expression," more nearly resembles the Asiatic gibbon than it does any ape of the New World, all of which have 36 teeth, whereas this specimen, like the Old World apes, had but 32, "without," says deLoys, "on the back portion of the mandible, any protuberances hinting at the possibility of a greater number of embryonic molar teeth." Likewise, the ape was tailless, whereas all South American monkeys possess long, prehensile caudal appendages.

It seems that American scientists are somewhat skeptical on the question of anthropoid apes in South America. For example, Dr. C. W. Stiles, of the United States Hygienic Laboratory, a well-known authority on the classification of apes and monkeys, said, through *Science Service:*

> I would not say that the discovery of an American ape is ridiculous. Many ridiculous things turn out to be true. If there is any possibility that an anthropoid ape has been found on this continent the discovery is of such importance that a scientific expedition should visit the region at once to verify the report. We might reasonably expect scientific investigators of Venezuela to handle this matter and give us the facts.

Dr. Francis M. Ashley-Montague, of the Royal Anthropological Institute of Great Britain and Ireland, contributed a most interesting dis-

cussion of Dr. deLoys' find to *The Scientific Monthly* (September, 1929, pp. 275-279). On the whole, he does not believe, on the evidence so far presented, that the creature killed and photographed—the actual remains of which were lost during the hardships of the forests—was an anthropoid ape. Dr. Ashley-Montague was furnished with two photographs of the specimen by Dr. deLoys, which are reproduced in the magazine just mentioned. Of these he says:

Careful inspection of these photographs reveals the following facts:

The human-like rounded head presents (a) a prominent forehead, and (b) there are no markedly overhanging brow-ridges; the nose is wide and presents a broad septum between the outwardly deflected nostrils—characters which are peculiar to the New World monkeys generally and specially to the genus *Ateles*.

It is a curious fact that none of the Old World monkeys and apes possesses a forehead as prominent as that found in many New World monkeys. The high forehead, which is so distinctively human a characteristic, is primarily what lends so human an appearance to the head of this creature, whose face is identical in appearance with most species of the genus *Ateles*. In no Old World monkey and in no ape, however, are the nostrils separated by a wide septum, nor are the nostrils so flaring and deflected in an outward and upward direction—this condition is peculiarly South American, there being only three New World genera in which there is an approximation to the Old World arrangement of a narrow septum and inwardly directed nostrils, namely, *Alouatta, Aotus,* and *Brachyteles*.

With the aid of a magnifying glass one may perceive that the thumb is a much reduced, nail-less tubercle, the merest excrescence upon the side of the hand. This is a characteristic which is specifically associated with *Ateles*, for no other South American monkey posseses so reduced a thumb. None of the Old World monkeys and apes possesses such a character; in only the orang-outan, in which the thumb is the most reduced but is quite large compared with this creature's, is the thumb occasionally lacking in a nail. It is clear enough from the photograph that this creature's hands are adapted to an extreme arboreal existence.

The feet are evidently of the quadrupedal grasping type, normally associated with an arboreal life. Doubtless, this creature could support itself on its hind legs, but the structure of its foot renders it quite impossible that its habitual gait is bipedal rather than quadrupedal, or that it spends more time upon the ground than in the trees. This foot is identical in appearance with that of *Ateles*. . . .

As far as the stature is concerned, I am not aware of any South American monkey which reaches a height of more than 90 cm. (three feet), although this height may conceivably be exceeded in some cases. Certain it is that the height of five feet two inches and the weight of 115 pounds of this monkey are quite unknown in any South American monkey. Nor would it appear from an examination of the photographs that these features are due to any anomalous or pathological causes, although such a possibility cannot be altogether eliminated. Assuming, however, that there does exist a species of monkey of which that figured here is a normal representative in the matter of height and weight, it becomes certain that we are here dealing with at least a new subspecies of monkey.

The idea that the anthropoids and man have arisen independently from lower forms in various parts of the world, and given rise to different types of races, is not new. The late Prof. Herman Klaatsch, like all other modern anthropologists, traced the origin of mankind to an ape ancestry, but came to the conclusion that the ancient inhabitants of Europe known as Neanderthal, or Mousterian, together with the living Negro peoples of Africa, had arisen from the same original stock as the chimpanzee and gorilla, whereas Mongolian peoples and men of the mod-

ern European type had sprung from the same lineage as the orang. This is a somewhat restricted form of Montandon's Ologenic Theory, and is known as the polygenetic origin of human races—a theory favored by very few modern authorities, since they do not care to rely on convergence and "parallelism" as against the fact that black and white races freely interbreed and are structurally very similar—only minor differences existing. As Sir Arthur Keith puts it, most modern authorities "rely on the axiom that likeness in structure means similarity of descent." (Klaatsch's theory was technically expounded in 1911, in his "*Die Stellung der Menschen im Naturganzen,*" and set forth in popular form in his book of 1923, "Evolution and Progress of Mankind.")

Dr. F. G. Crookshank, an eminent British medical expert, wrote a little book for the "Today and Tomorrow Series" called "The Mongol in Our Midst," in which he adduced evidences from his experience as a hospital director that seem to support, in a general way, Klaatsch's polygenetic theory. Dr. David Starr Jordan, in his recent book on what he designates as "sciosophy," what Dr. Edwin Grant Conklin calls "thinking wishfully," and what Henshaw Ward has named "thobbing," places Crookshank among "sciosophists," those who facilely evoke discoveries "without the hard mental grind which exalts itself as 'research.'" The fruits of this method, he says, are swift and varied. "Accordingly a recent English writer proves without effort the separate origin of the three great primal races of man. These, it appears, sprang from three different species of ape: the Aryan races (Nordic, Latin, Slavic, and Hindu) from the chimpanzee; the Mongolian from the orang-outan; the Negro from the gorilla. The occasional occurence, in the white race, of morons (senselessly called Mongol by certain eugenists) proves that there has been an admixture of orang blood among the common people, descendants of the chimpanzee. Thus with feet shod with analogies, anthropology can move as merrily as astrology, . . . and is now beginning to do so" ("The Higher Foolishness," p. 73).

This does not seem entirely fair to Dr. Crookshank, who bases his theory mostly on the sitting posture of the various races, but gives a great deal of other suggestive evidence. Moreover, it does not exactly represents his theory; for example, he includes the Jews among the chimpanzee-descendants. And so-called Mongoloids are technically idiots, not morons.

CHAPTER X

AN APE INTERMEDIATE BETWEEN LIVING ANTHROPOIDS AND MAN?

DURING November, 1924, there was brought to Dr. Raymond A. Dart, professor of anatomy in the University of Witwatersrand, at Johannesburg, South Africa, by one of his students, the fossilized skull of an ape, still partially embedded in limestone. This skull had been found in a lime cliff at Buxton, nine miles west of Taungs, in Bechuanaland, South Africa, by one of the directors of the Northern Lime Works, which was working this huge lime deposit.

In this deposit occur patches of lime and infiltrated sand, representing old caves in the lime, which during the course of untold ages have been entirely filled up with sand, carried into the formation by underground river action from a long distance away.

It appears that similar skulls, limb bones, and even fairly complete skeletons had been found from time to time, but thrown away by the workmen. Dr. Dart asked that further specimens be saved for him; and the very next week some blocks of stone bearing traces of bone were blasted out and brought to the university by Dr. R. B. Young, professor of geology. To continue the story in Dr. Dart's own words:

One of these pieces of stone I immediately recognized as the cast of the cranial cavity of a creature which was closely related to the largest living anthropoid apes, but more intelligent.

This cast in stone of the creature's brain case was found to fit accurately by its front end into one of the larger rock fragments, so one recognized that the facial skeleton of the creature must be present in this solid block of limestone.

A month of steady work first with hammer, chisel, and saw, and later with sharpened, knitting needles, and meat skewers, proved this to be the case.

Then there stood revealed, intact and uncrushed, virtually the entire face of a baby—the first record of a group of creatures long since extinct, but which were more human in features and in brain power than any anthropoid apes now living on the face of the earth.

Professor Dart declares that it seems probable, in view of this and other new and important discoveries connecting the early history of man with Africa, that the Darwinian claim that Africa is the cradle of mankind may be substantiated.

This group of beings, having acquired the faculty of stereoscopic vision, had profited beyond living anthropoids by setting aside a relatively much larger area of the cerebral cortex to serve as a storehouse of information concerning their objective environment as its details were simultaneously revealed to the senses of vision and touch and also of hearing. . . . They possessed to a degree unappreciated by living anthropoids the use of their hands and ears and the consequent

faculty of associating with the color, form, and general appearance of objects, their weight, texture, resilience, and flexibility, as well as the significance of sounds emitted by them. In other words, their eyes saw, their ears heard, and their hands handled objects with greater meaning and to fuller purpose than the corresponding organs in recent apes. They had laid down the foundations of that discriminating knowledge of the appearance, feeling, and sound of things that was a necessary milestone in the acquisition of articulate speech.

There is an ultra-simian quality of the brain depicted in this immature endocranial cast which harmonizes with the ultra-simian features revealed by the entire cranial topography and corroborates the various inferences drawn therefrom. The 2,000 miles of territory which separate this ceature from its nearest living anthropoid cousins is indirect testimony to its increased intelligence and mastery of its environment. It is manifest that we are in the presence here of a pre-human stock, neither chimpanzee nor gorilla, which possesses a series of differential characters not encountered hitherto in any anthropoid stock. This complex of characters exhibited is such that it cannot be interpreted as belonging to a form ancestral to any living anthropoid."

Since the day its discovery was announced through the press, the Taungs skull, which Dart named *Australopithecus* (southern ape), comparable to a human child of four or five years, has been a subject of controversy among experts. This is not the place to set forth the diverging views of competent anthropologists, since only two or three scientists have actually examined the skull, others forming their opinions from study of the casts.

While it is admitted by all that the *Australopithecus* is allied to the chimpanzee, there are many points on which it differs from both the chimpanzee and the gorilla.

That eminent anatomist Dr. Richard Broom, writing in *The Scientific American* for August, 1929, p. 121, says of this interesting fossil skull, among other interesting conclusions:

The milk teeth differ entirely from those of the chimpanzee and gorilla, and agree very closely with those of man. The brain is of the human shape and shows certain very marked advances in the human direction, from the brain of the chimpanzee or gorilla. The bones of the temporal region are also much more like those of man than of either of the other anthropoids. Dart has shown further that the head must have been poised much more erect[ly] than the head of either the chimpanzee or gorilla, and thus that *Australopithecus* must have walked more erect. If he walked more erect he must almost certainly have been bipedal. I venture to prophesy that when the hind foot is discovered, it will show that it approaches the foot of man in a surprising way. . . .

There is another most important point. Taungs today is in a very dry region, and among the rocks and open forests the only monkeys are baboons and little apes. Associated in the cave where *Australopithecus* was found, are numerous skulls of a species of baboon, sufficiently satisfactory evidence that the climatic conditions when *Australopithecus* lived were very similar to those of today, and we can be quite certain that *Australopithecus* was a rock-climbing, plains-living and not a forest-inhabiting animal.

Dart, with the intuition of genius, boldly made *Australopithecus* the type of a new family intermediate between the higher apes and man. This was perhaps a little daring on the evidence, and most of his critics have considered that in this he was wrong. But if when a good skeleton is discovered, as it probably will be in a very few years, it is seen that *Australopithecus* has a foot approaching the human foot, as I believe will be the case, Dart will be thoroughly justified in his conclusions. . . .

Sollas has shown that the skull differs very greatly from that of the chimpanzee, and concludes that "*Australopithecus* makes a nearer approach to the Hominidae than any existing anthropoid ape." Surely science has advanced sufficiently far to enable one to determine something of the affinities of an anthropoid ape from a single but good skull of even a young individual. . . .

Hrdlicka, the eminent American anthropologist, recently visited South Africa and saw this wonderful skull. He says, "The skull itself is that of an anthropoid ape approaching rather closely in size and form the chimpanzee, but in all probability it is a new species, if not genus, of the great apes. . . . Just what the relation this form bears on the one hand to the human phylum, and on the other to the chimpanzee and gorilla, can only be properly determined after the specimen is well identified, for which are needed additional and adult specimens."

As to the age of the deposit, although it cannot be exactly determined, it is very old. Broom thinks it is probably either Pliocene or Pleistocene, but if Pleistocene, then certainly early Pleistocene.

CHAPTER XI

FOSSIL CONNECTING LINKS IN MAN'S HISTORY

THE lowest type of human skull so far discovered was found by Dr. Eugen Dubois, a Dutch army surgeon, in 1891, on the Bengavan, or Solo Rive, in central Java. Only the skull-cap remained. A human upper molar tooth had been found about one meter (=3.28 ft.) distant from where the skull appeared. Some months later, at the close of the rainy season, a second molar tooth and a left thigh-bone were unearthed, embedded and fossilized in the same manner as the skull. In 1894, Dubois described these fragments as the type *Pithecanthropus erectus,* a term signifying "upright-standing ape-man," an erect posture being in perfect harmony with the structure and form of the femur. Dubois's studies led him to the conviction that he had discovered "the transition form between man and the anthropoids which the laws of evolution teach us must have existed. He is the ancestor of man."

In a conversation with Professor Dubois's son only a few years ago, he told me that his father still adhered to his conclusion of 1894. Until quite recently, zoologists and anthropologists were still divided in opinion on the question of whether we had to deal here with a high type of gibbon or a low type of human. The problem is not yet fully settled, but it would appear that the conviction is rapidly gaining ground that the Trinil (Java) skull is fully entitled to human rank. The volume of the gorilla brain is only 57 per cent of that of the Javan man, and that of the latter is 72 per cent of the Piltdown man. The femur of *Pithecanthropus* is certainly human-like.

Dr. Wilhelm Gieseler, of the University of Munich, in 1928 came forward with the theory that the legs of human beings evolved in advance of the skull. The legs of the Broken Hill Man (Rhodesia) are much like those of modern man, while his skull is Neanderthaloid. Of this Rhodesian Man, Sir Arthur Keith remarked, in *The Illustrated London News* of November 19, 1921:

> The revelation now made in Northern Rhodesia extends the habitat of this ancient and extinct type of humanity far into Africa, for the site of the Broken Hill Company's work lies 4,000 miles from southern Europe. We now seem to be tracing Neanderthal Man toward his cradle-land, for in many of its features the Rhodesian skull is more primitive than European specimens of the same type.

The Heidelberg jaw is distinctly human in point of dentition, but rather ape-like in some features. No other parts of the skull of this race have been found, but there are sound reasons for placing them with the Neanderthals, who are now represented by more than fifty individuals. The far more advanced Crô-Magnon race, regarded as immigrants from

Asia, and certain related races, include 82 individuals. Nearly 150 skulls and skeletons of fossil men are now to be seen and studied in the world's museums. The monkey and ape fossil series is also gradually being filled in with representative evolutionary types, from Pro-Lemurs to Man.

Dr. W. K. Gregory concludes his splendid chapter on "The Lineage of Man," in "Creation by Evolution" (a symposium on evolution, ably edited by Frances Mason), in these words, which I quote, as my own conclusion, for the enjoyment of any anti-evolutionist readers:

> The natural egotism of man has made him easily credulous of the story that the first man, although made from the dust of the ground, was also created perfect in the image of God. The knowledge that man has struggled upward to his present estate from less intelligent animals is still practically denied to the majority of mankind.
>
> The gospel of evolution as outlined above is not the writer's invention; it has not been built up, like early systems of religion, in an endeavor to propitiate the gods without; it is simply a very condensed outline of what Nature is gradually revealing to those who carefully examine her records. When man fully realizes what he has come from and the long, slow steps by which he has reached his present condition, he will be better able to apply intelligent measures toward correcting his infirmities and toward guiding his evolution along profitable paths in the future.

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