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Evolution and the Darwinian Theory of Human Descent Viewed from the Standpoint of a Multiple Primate Ancestry

BY
DR. CHARLES K. MILLS

Papers and Discussion of the Paper by Dr. Mills

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DISCUSSION ON EVOLUTION *

EVOLUTION AND THE DARWINIAN THEORY OF HUMAN DESCENT VIEWED FROM THE STANDPOINT OF A MULTIPLE PRIMATE ANCESTRY. DR. CHARLES K. MILLS.

Before taking up the particular subject set apart for this meeting, namely, evolution and the darwinian theory of human descent, let me turn aside to glance at the last meeting of this society (The Philadelphia Neurological Society, Oct. 28, 1927). I was strongly impressed with the vitality of Philadelphia neurology which this meeting demonstrated. Old but not outworn subjects were newly elucidated, and important original ideas were presented. The cases shown were unusual and well described. The differential diagnosis of cerebral thrombosis and hemorrhage was discussed by contributors who enforced their statements by records of actual work, clinical and pathologic.

The alluring question of the presence or absence of consciousness in apoplectic attacks, thrombotic or hemorrhagic, was placed on a firmer basis than ever before by the actual experiences of men who have given their days and nights to hospital and laboratory work. Originality was exemplified by the paper on thrombosis of the superior cerebral vein, in the study of cerebral toxemia and infections with the production of rheumatic nodules, and in the discussion of the question of lesions of the choroid plexus in their relation to so-called essential epilepsy. To the veterans of this society — to men like Lloyd, Dercum and myself — it is a matter especially gratifying to know that the neurologic work begun in this society forty years ago is in not only a healthful but in an advancing state.

The rest of the paper by Dr. Mills is to be found in the *Archives of Neurology and Psychiatry* for June, 1928, vol. 19, No. 6, pp. 969-980.

EARLY STUDIES IN MORPHOLOGY OF THE BRAIN WHICH BEAR ON THE ANTHROPOID RELATIONS OF MAN. DR. FRANCIS X. DERCUM.

In the early days of the Philadelphia Neurological Society, we were all greatly interested in the theory of evolution which at that time occupied the attention of leading scientists all over the world. We all greedily read the writings of Darwin, Huxley, Spencer and Ernst Haeckel. To these names that of Dr. Joseph Leidy should be added. Dr. Mills early made contributions on the brains of criminals and defectives, while A. J. Parker and myself enjoyed special advantages during our student days. Parker was a special student of Joseph Leidy, while I was a special student of Henry C. Chapman. Chapman was Dr. Leidy's prosector and occupied Leidy's rooms in the building now known as Logan Hall of the University. This gave me access to Dr. Leidy's rooms, Dr. Leidy himself furnishing me with a key. Dr. Chapman had an excellent library on comparative anatomy and histology and also two excellent microscopes, all of which, I need hardly say, added greatly to the happiness of Parker and myself. Chapman was at that time the prosector to the Zoological Garden, and a great mass of most interesting material was sent to the University. Parker and myself gladly aided Dr. Chapman in the studies and dissections that ensued, in which it is unnecessary to add that Dr. Leidy took a lively interest. Among the specimens that were preserved were a number of simian brains and, as I recall, the brains of two chimpanzees. I myself, became interested especially in the intracranial portion of the sympathetic nervous system and included in my dissections quite a number of the primates. At this time, Parker became much interested in the morphology of the cortex

* Papers and abstracts of papers and discussions presented before the Philadelphia Neurological Society, Nov. 18, 1927.

of monkeys and anthropoids, and realizing that his studies outranked in importance those which I was making I readily consented to his having all of the brain material. In this attitude Dr. Henry C. Chapman generously concurred. During my last year at the university, Prof. F. Gurney Smith, professor of physiology, died, and Dr. Chapman was requested to complete the course, which he did brilliantly. It so happened that at that time a group of clinical teachers, headed by Dr. William Pepper and H. C. Wood, were clamoring for revolutionary changes in the faculty, and as the changes threatened — or seemed to threaten — the security of such didactic teachers as Dr. Leidy, Dr. Chapman threw himself into the breach and opposed vigorously changes which seemed to him to be too radical in their nature; as a result, he was not elected to the professorship of physiology. About this time, however, the professor of physiology of the Jefferson Medical College, Dr. James Aitken Meigs, died and Dr. Chapman was triumphantly elected to succeed him. That Dr. Chapman taught most efficiently for many years at the Jefferson College is a matter of history. The fact that I was myself called to the Jefferson years later to join him as a colleague in the Jefferson faculty was to me a source of great pride and joy.

Dr. Parker's studies won for him one of the graduation prizes. His paper was, however, not published for many years. After his death the manuscript fell into my hands and I at once made an effort to secure the necessary funds for the cost of the illustrations. In this I was generously aided by Dr. Mills, Dr. Osler and others. In due course it appeared among the *Proceedings of the Academy of Natural Sciences.* It formed a large volume with many plates.

These events are now between 40 and 50 years old. Dr. Mills, like Parker and myself, and because he was especially interested in cerebral localization, was thoroughly imbued with the importance of studies in the morphology of the cortex. Parker did not take any interest in clinical neurology, but he did take part in our discussions on cerebral morphology and at one time made a joint study with Dr. Mills of a Chinese brain. Dr. Mills made numerous morphologic studies. I studied and made reports on the morphology of the brains of imbeciles, idiots and epileptic persons, the brains of murderers, and I also described three Chinese brains. We early formed the conception of low type brains. We noted in such brains the frequency of unusual confluences of fissures, and we rightly attributed such confluences to failure of the cortical tissue in the given areas to develop to the general cortical level. Of course we noted relative simplicity of frontal, parietal and temporal development from time to time, but our attention after a time became especially directed to the relations between the parietal and occipital lobes. One of the features by which the anthropoid and simian brain generally is characterized is that the relationship between the occipital lobe and the great association areas of the parietal and temporal lobes is much less close than in man. A distinguished French anatomist, Gratiolet, had early called attention to certain convolutions of the human brain which intimately connect the occipital with the parietal lobe, and he called these convolutions folds of passage, plis de passage. Anomalies of the human brain, therefore, in this region came to be regarded by us as of special significance. The parieto-occipital fissure, for instance, in the normal white brain does not extend, except to a limited degree, on the lateral surface of the hemisphere. When it reaches the mesial edge of the hemisphere it is bounded by a well developed convolution which Gratiolet termed the plis de passage supérieure externe. It does not extend on the lateral surface. In the simian brain it not only extends well on the lateral surface but serves as a distinct demarcation between the occipital and parietal lobes. When it was on the lateral surface of the hemisphere, we spoke of it as the external perpendicular fissure, while to the parieto-occipital fissure the name internal perpendicular fissure was applied. I regard the name external perpen-

dicular fissure as preferable to the term sulcus lunatus employed by Elliot Smith. The name "Affenspalte" (ape cleft) employed by some of the German writers is significant. It is also known in the human brain as Wernicke's fissure.

A close relationship between the occipital lobe and the parietal lobe seems to have been the direct result of the change from the quadrupedal to the bipedal attitude. The more that progression became relegated to the posterior or lower extremities the more did the anterior or upper extremities, the arms and hands, become free to grasp, to handle and to examine objects. In the occipital lobes reside not only the function of vision but also such cognate functions as the perception of perspective, of distance, of depth and of the relations of objects in the field of vision to each other. These functions reside in what may be called the visual association areas, whose correct functioning depends on motor centers situated elsewhere, which we need not now consider. Obviously, when an ape form progressed to such an extent that its upper extremities, its hands, were left free to examine objects tactually and to note size, weight, smoothness, roughness, hardness, softness and the other qualities that make up stereognostic perception, it examined the object at the same time with its eyes, and the stimulation of the interplay between the parietal lobe with its great tactual association area and the occipital lobe led to a closer morphologic relationship and to the development of such bridging convolutions as the pli de passage superiéure externe. The failure of a brain to develop the pli de passage supérieure externe is justly to be regarded as an evidence of a developmental failure and therefore of a low type brain. Together with peculiarities of like significance, it was especially pronounced in the brain of one of the murderers that I examined.

The change to the erect posture appears also to have been accompanied by a lessened necessity for the presence of another pli de passage; namely, the pli de passage inférieure interne. This pli de passage allows a free interchange between the mesial surface of the occipital lobe and the callosomarginal gyrus, but in man it has become submerged or is altogether absent.

Time will not permit my dealing with this point in detail, but the fact is so interesting that I cannot refrain from alluding to it. Normally, the parieto-occipital fissure terminates in the calcarine fissure. In an examination of thirty-three brains of negroes, made by A. J. Parker, he discovered two instances in which a confluence did not occur between these fissures. They were separated by a well developed convolution; this convolution Gratiolet termed the pli de passage inférieure interne. In the apes this convolution is constant except in *Hylobates* and *Ateles,* but it is almost uniformly absent in the human brain. (The submergence or loss of the pli de passage inférieure interne in the case of such widely separated forms as the gibbon, an Asiatic anthropoid, and the spider monkey, a South American primate, may fairly well be regarded as an instance of "parallel evolution." It is of extraordinary interest, however, to note that the extreme length of the arms in both forms spontaneously brings about an erect position.) The finding of this convolution in two instances in the brain of the negro is therefore highly significant. In the white brain it was found by Dr. Mills in only one instance, and that was in the case of a murderer. Benedikt of Vienna had also described the brain of a criminal in which the calcarine was separated from the parieto-occipital and put on record also a similar condition which he found in a Chinese brain. I had the privilege of going over the collection of brains of idiots made by Dr. Wilmarth of the Elwyn Institution for Feebleminded Children. Among seventy-five brains, I found four instances of the presence of such a pli de passage. Two of these existed in opposite hemispheres of the same brain. In both instances the convolution was large and well developed. In addition, it was twice found (in the same brain) barely submerged. All of these brains in which the convolution occurred were those of white low grade idiots. The presence of a pli de passage inférieure interne is therefore beyond all doubt evidence of a low type brain.

In the Chinese brain studied by Dr. Mills and Dr. Parker, in those studied by Benedikt of Vienna and in the three that I studied by myself, many peculiarities were noted. Prominent among these were numerous and unusual confluences of fissures. I formed the general conclusion that these facts were expressive of failures of cortical development in given areas. Certainly, such appearances are relatively rare in the white brain. This fact becomes possibly significant when one recalls that similar conditions are frequent in the brains of negroes and largely obtain in the brains of apes. This is especially true of the confluence between the parieto-occipital and the hippocampal, the presence of a deep and well differentiated external perpendicular, and the consequent absence of the various external plis de passage. In noting these features of the Chinese brains, it is important to bear in mind that all of the brains examined were those of Chinese coolies. Doubtless the brains of Chinese of a higher social, that is, of a higher biologic level, would reveal a different series of facts.

It may be interesting to recall the conditions noted in some of the brains of epileptic persons that I studied. The absence of a pli de passage supérieure externe occurred in seven of twelve epileptic brains, and as a result of the confluence of fissures the parieto-occipital fissure became an external perpendicular fissure extending far out on the lateral surface. Many other features of similar significance were noted in other regions of the brain. Taken together with the numerous general morphologic features of epileptics, also repeatedly noted, they were expressive of the general truth of the failure of epileptic persons as a group to reach the level of the average normal organism. It is an amazing and regrettable fact that morphologic studies of the epileptic and insane have gone into the discard.

While it is necessary to be cautious in the inferences to be drawn from the facts which I have here called to mind, one conclusion may be safely drawn: namely, that they are in keeping with the general truth that the organism in the course of its development passes through or rehearses in a measure the various stages through which its ancestors have passed and, second, that when through biologic inferiority or through some pathologic cause the development ceases before the highest level of development is reached, the stage at which the arrest takes place represents, other things being equal, a primitive stage in ancestral evolution.

EXHIBITION OF AND COMMENT ON CASTS OF FOSSILS OF PITHECANTHROPUS ERECTUS. DR. FRANCIS X. DERCUM.

As is well known, the fossils of *Pithecanthropus* were discovered in 1891 and 1892 by Eugene Dubois, who was at that time a surgeon in the Dutch Colonial Military Service, at Trinil, Java. The fossils, which were believed to have had their origin about 500,000 years ago, were found in a bed of volcanic ash in which there were also a great number of fossils of other extinct animals. The fossils to which the name *Pithecanthropus* came to be applied — a name which had been previously proposed by Ernst Haeckel to designate a "missing link" (at that time still hypothetic) — consist of a calvarium, four teeth including a fragment of a lower jaw, and a left femur. These fragments have been elaborately studied by Dubois and by others, and of late again by McGregor of Columbia University and the American Museum. These remarkable fossils, however, remain perpetually new, and their study is ever rich in new thoughts and interpretations. However, I will confine myself to a mere presentation of the most salient and significant features. The calvarium is much smaller than that of modern man and yet is much larger than that of any of the anthropoid apes. One can see at once that the frontal, parietal and occipital regions are much less prominent, much less developed, than the corresponding regions of the human calvarium; in fact they impress one at once as being definitely less "bulging." Again, the frontal region slopes down rapidly from the bregma and terminates in two large and prominent supra-

orbital ridges, which suggest on the one hand the supra-orbital ridges of the gorilla and on the other those of the Rhodesian man. Compared to the ordinary human skull, these ridges are relatively enormous. Further, running laterally from either side of the occipital protuberance there is a well marked ridge, which evidently existed for the attachment of powerful nuchal muscles, and the slope of the occipital bone is such that the head was carried or "hung" forward, much as the anthropoid apes do, and not equipoised, as in modern man.

When found, the calvarium was filled with a hard deposit, and some time later this was carefully removed by Dubois. In the comparison of a cast of the interior of the calvarium of *Pithecanthropus* and the cast of the brain of a modern man, so-called *Homo sapiens,* one will at once be impressed by the striking difference in size; the brain of modern man is greatly larger than that of *Pithecanthropus.* Dubois estimated the size of the latter as equivalent to 900 cc.; McGregor, as equivalent to 940 cc. That of modern man ranges from 1,300 to 1,600 cc. and much more. That of an Australian bush woman was estimated by Turner as 930 cc. Other instances of brains of less than 1,000 cc. capacity are on record. However, the largest brain of a gorilla, according to Keith, rarely exceeds 600 cc. In size, the brain of *Pithecanthropus* is much nearer to that of man than to the anthropoids.

When one examines the cast of *Pithecanthropus,* one must bear in mind that this is not a cast of the brain itself but merely a cast of the interior of the skull and that in interpretation one must make allowance for the presence of and the space originally occupied by the dura and its vessels, by the cerebrospinal fluid, by the arachnoid and by the pia. One notes at once, in spite of the rôle which these structures must have played in the final result of the process of fossilization, definite cortical landmarks. For instance, one notes in the frontal lobes the outlines of the three typical convolutions and also similar demarcations on the occipital lobes indicating, though less clearly, the convolutions, while on the parietal and other lobes the demarcations are much less defined. In interpreting these results, one should remember that the bones of the vault of the skull are membrane bones, that they are relatively soft and that in the young and growing animal they readily receive and accept the impression of the rapidly developing brain. All who have dealt with the roentgenograms of the skulls of children will recall many pictures of convolutional impressions on the inner table of the skull. Such impressions are not to be regarded as due to abnormal increase of intracranial pressure, or indeed to any other pathologic cause, but are to be regarded as normal and physiologic. In keeping with this one notes that in the frontal region of the cast the convolutions are outlined with a special clearness; doubtless this is due to the fact that the frontal bone is especially impressionable, particularly in the young. This is true to a less extent of the supra-occipital and still less of the parietals.

It is interesting to note that in the cast the sylvian fossa is clearly marked. The fissure of Rolando is only faintly indicated, owing to the dominance of the dura with its vessels. In the occipital region, especially on the right hemisphere, is indicated the external perpendicular fissure (the Affenspalte, the sulcus lunatus). Both the third frontal convolution and the temporal lobe (as far as preserved) justify, from their development, the inference that *Pithecanthropus* had in a measure the faculty of speech.

The teeth are distinctly pithecoid and suggest those of the orang. One observer, indeed, Gerrit S. Miller, looks on them as the teeth of an extinct Javan great ape. Keith, Gregory and others, however, find important similarities to human teeth. Evidently these fossil teeth, like the calvarium and the brain, occupy an intermediate position. The fragment of jaw, which bears a left anterior premolar, shows that *Pithecanthropus* had a vertical chin, which did not project like that of modern man.

The thigh bone is thoroughly human; it is massive but decidedly shorter than the thigh bone of modern man. The large linea aspera which still bears some of the tendinous insertions of muscles leaves no doubt as to the erect posture of *Pithecanthropus.*

These remarkable fossils, as just stated, are ever new, and a number of interesting and important inferences and interpretations, which have not as yet been presented, suggest themselves. However, other and more general statements are, it appears to me, called for. For instance, it is interesting to recall the following well known facts, to which Keith among others directs attention: (1) the forms of fossil man from the older strata are more ape-like than those from the newer; (2) in still older strata, one finds the fossils of great anthropoids — some nine in number; (3) in still more ancient deposits, the remains of small anthropoids; (4) deeper still, no anthropoids, merely monkey-like primates.

All mammalian life appears to have been arboreal in origin. This is clearly true of the primate ancestors of man, who were entirely arboreal. The anthropoid ancestors of man were semiarboreal and semiterrestrial; most of the time was spent in the trees, but they occasionally descended to the earth. This is true of the four living anthropoids and was apparently true of all of the fossil anthropoids with a single remarkable exception. About two years ago, a fossil anthropoid was found which had been purely terrestrial. It was described by Prof. Raymond A. Dart, Professor of Anatomy in the University of Witwaterstrand, Johannesburg, South Africa. It was named by him *Australopithecus*. It had ceased to be an arboreal creature; it had become a cave dweller; it was entirely terrestrial. Lack of food or powerful enemies had driven it out of the tropical forests and across a large open treeless country. This country was, as fossils show, inhabited by enormous carnivora, great cats; self preservation here demanded of this anthropoid the utmost ingenuity and alertness. Safety was at last found in the caves of the limestone cliffs of the Taungs in Bechuanaland.

In the Taungs an enormous and radical change was forced on this anthropoid. All the anthropoids of which there is any knowledge, both the living anthropoids of the present day as well as their progenitors and relatives of bygone times, were fruit eaters. They were not only arboreal or semi-arboreal, but depended for their sustenance entirely on the fruits of the forests and possibly on such nutritious roots as the soil afforded. Under the new surroundings in which *Australopithecus* found himself, there was only one choice between starvation and survival, and this consisted in a change of food; a change of food evidently took place. Hunger permits no hesitation and clearly forced *Australopithecus* to seize and feed on the other living creatures about him. In the fossilized deposits and accumulations in the cave in which the skull was found were hundreds of fragments of bones which had been obviously gnawed; bones of turtles, birds, small insectivores, rodents, baboons and perhaps small bok, and there were also fossilized egg-shells. "The material indicates by its nature, its sparsity, its searched-over character, the careful and thorough picking by an animal which did not live to kill large animals but killed small animals in order to live." Many skulls of baboons had been fractured, doubtless with the aid of a stone, and the nutritious brain material scooped out. No doubt the breaking of other bones gave access to the marrow. From an animal whose ancestors had lived entirely on fruits and vegetables, *Australopithecus* became a carnivorous, or in all probability an omnivorous, animal; for he no doubt found also some vegetable matter, roots, berries, etc., sparse and inadequate as it may have been.

Unlike the gorilla, *Australopithecus* was slight of build and, it would seem, small of muscle. The superciliary ridges, too, were slightly developed; in the gorilla, they are massive. The dentition and jaws were moderate in development and did not suggest an animal that fought with its teeth. The skull revealed a large frontal and, it may be added, also a large occipital development. In other words, in contrast to the gorilla, which in its struggle for existence had developed enormous physical strength, *Australopithecus* had remained physically weak and relatively defenseless; but, on the other hand, his brain under the constant stress of outwitting his enemies and of searching for food, had undergone a development far in excess of that of the other

anthropoids. The discovery of *Australopithecus,* which occurred only a little more than two years ago, has opened up great vistas in the history of both anthropoid and human evolution. Dart estimated the cranial capacity of *Australopithecus* at 625 cc.; he regards *Australopithecus* as intermediate between the chimpanzee and *Pithecanthropus.* After *Pithecanthropus,* one would come to a man at the level of the Piltdown man, *Eoanthropus* (Dawson), then to the Heidelberg man, the Neanderthal man, the Rhodesian man, the Cromagnon man and, finally, modern man. It is not claimed, of course, that all of these forms are ancestrally related to each other; but that they represent stages and periods in the history of human evolution there can be no doubt.

THE RÔLE OF THE CATALYSTS IN EVOLUTION. DR. FRANCIS X. DERCUM.

In his address on "Darwin's Theory of Man's Descent, as it Stands Today," read before the British Association for the Advancement of Science on Aug. 31, 1927, Sir Arthur Keith called attention to the possible rôle of the hormones in evolution. In my address, "On the Dynamic Factor in Evolution," delivered April 28, 1927, at the Inauguration of the Bicentenary of the American Philosophical Society, I expressed myself on this theme as follows: It has long been known that certain substances may induce changes in other substances merely by their presence, they themselves not undergoing any change whatever. For instance, dilute sulphuric acid added to starch will convert the latter into glucose, the acid itself neither qualitatively nor quantitatively undergoing any change. Again, hydrogen peroxide is decomposed by soluble alkalis, also by the mere presence of insoluble substances such as metallic silver or metallic platinum; these substances, as before, do not undergo any change. A similar statement applies to the action of platinum in bringing about the oxidation of alcoholic vapor and to the action of spongy platinum in bringing about the union of hydrogen and oxygen. Similar truths apply to both gold and silver, though neither are as active as platinum. The various substances enumerated, it should be mentioned, may perform the rôle, on the one hand, of reducing agents or on the other, of constructive agents, the chemical bodies resulting being either more simple or more complex in structure. Such action, I need hardly state, is termed catalysis. It implies more especially the setting in motion or the precipitating of possible or impending chemical changes. The action is one in which given substances by their presence alone set into activity chemical processes otherwise dormant without themselves suffering any chemical change. Some facts are especially suggestive; for instance, in the union of hydrogen and oxygen, brought about by the presence of spongy platinum, the enormous increase of surface in the spongy platinum is the immediate causative factor of the union. Such facts as these, so well known, are, I believe, of the utmost importance in interpreting the phenomena of living matter.

It is hardly necessary to call to mind the fact that when a food particle is taken into the interior of an ameba, it gradually disappears and finally becomes part of the substance of the ameba. It would appear that, as in higher animals, the protoplasm of the ameba has the power of fragmenting proteins, fats and carbohydrates. In the higher animals, protein is reduced successively into peptones, amino-acids and a series of intermediate products until the final stage of urea, uric acid and kindred substances is reached. Carbohydrates are by a long series of intermediate stages converted into carbon dioxide and water. Fats, also, are decomposed into glycerin and fatty acids and by a further reduction into simpler bodies until end-products are likewise reached. During these changes, energy is released. There is no inherent improbability in the inference that changes like or analogous to these take place in the ameba. Certain it is that the various food particles are so metamorphosed that they disappear into the general substance of the organism and after a time can no longer be distinguished. Evidently they have added to the substance of the ameba. Facts and inference both justify the statement

that physical increase of size and final separation or division into two bodies follow the continued ingestion of food; and this constitutes the second fact of importance, for it means that *the constructive or upbuilding change far exceeds the reducing change.* That which is observed in the ameba, it is needless to say, is true of other living forms and, to state it in other and more familiar words, living protoplasm is the seat at one and the same time of both anabolic and catabolic processes, of both an upbuilding and a down building change. The fact that the upbuilding process exceeds the down building process is one of great significance. Growth and multiplication both have their explanation in this fact. Various terms, it need hardly be added, have come to be applied to the substances instrumental in inducing these changes, such as enzymes, ferments and hormones, but the general term catalysts can be conveniently applied to them all; and the inference further is justified by the facts at our command that their action in no way differs from that of catalysts of the non-living world, for like the latter they act merely by their presence. How intensive this action may be is illustrated by the fact that under the influence of enzymes or ferments, chemical changes take place in living organisms which can only be brought about in the laboratory by powerful reagents and high temperatures. For example, the change of protein to amino-acids is effected in the laboratory by boiling in concentrated hydrochloric acid. In the organism it takes place at an equal rate at ordinary temperature and in a medium which is only just faintly alkaline or neutral (Bayliss: Principles of General Physiology, ed. 3, 1926, p. 301).

With these conceptions of catalytic action, both in the non-living and the living world, one may consider the possibilities of the origin of living matter; namely, as the result of gradual changes taking place and extending over vast periods of time and resulting from the interaction, combination and association of previously existing substances and in conformity with natural laws. In all probability, the complex substances that were thus formed consisted at first of exceedingly minute molecular aggregations. These resulted, doubtless, from the synthesis of less complex bodies. The very fact of such a synthesis implies the early action of catalysis on the part of the intermediate and primitive bodies, bodies which today no longer have existence on the earth. Little by little these aggregates became more and more complex and gradually and in an increasing degree manifested properties which one to-day associates with living matter. At first these aggregates were without definite structure, unless one considers their possible molecular arrangements as structure. They were also without definite form, though it is safe to infer that they were rounded bodies. Little by little and in increasing degree, they manifested properties which finally were frankly those of living matter; namely, constant chemical interchange with the environment, constant increase and constant diminution in substance, all of these phenomena being inextricably interlinked with and dependent on the ever increasing catalytic power of the aggregate. The living protoplasm of today has become the complex aggregate that it is because of the catalytic power of its primitive proteins to force other materials, often of vastly different chemical structure, into association with itself. "Life," it may be assumed, has thus made its appearance. It may now be traced further.

According to the views formulated by the biochemist of McGill University, Prof. A. B. Macallum (*Physiol. Rev.*, April 1926, vol. 2, no. 2), life originated in the ocean water of the archean period, and the earliest organisms must have been of the micellar or ultramicroscopic kind. Later, these micellar organisms gave rise to multimicellar aggregates and still later these gave rise to simple and undifferentiated cellular forms from which in turn others evolved which were less simple and approximated in complexity the simplest living organisms of today. Further, these organisms synthesized their own constituents from the available nitrogen and carbon dioxide from the air, the sulphur from the sulphates, the phosphorus from the phosphates and the iron from the sea water. There was as yet no nucleus.

This interpretation by Macallum seems to me to bear within it the inherent probability of truth. It is a legitimate inference, further, that the synthesis outlined by Macallum resulted in the formation of amino-acids and the association of the latter into groups to form proteins. Probably the formation of proteins occurred long before the cellular stage was reached, indeed, at the time the first molecular aggregations made their appearance.

After the formation of proteins, the next important step was without doubt the differentiation of nucleoproteins and their grouping together to form the nucleus of the cell. According to Macallum, the contents of the normal cell nucleus does not know the inorganic world. "It contains not a trace of potassium, or of chlorides, phosphates, carbonates or sulphates, and accordingly no sodium, calcium or magnesium, although these four elements are found in the cytoplasm." When one considers the remarkable rôle which the nucleus plays in the process of cell division, it suggests at once that the nucleus dominates the cytoplasm. In other words, while the cell contents as a whole probably possess catalytic powers in varying degrees, the dominating catalytic power resides in the nucleus. Judging from the facts, it would appear that the ions of the alkaline and earthy bases are automatically excluded from the nuclear material. Possibly to this exclusion is due this dominating catalytic power of the nucleoproteins. It would appear that the presence of crystaloids would tend to inhibit this catalytic power.

A protoplasmic mass with differentiated nuclear material having once made its appearance, a further differentiation next took place. Two protoplasmic aggregates coming into contact or within the range of physical or chemical, or shall one say of catalytic, reaction with each other, the mass possessing the greatest catalytic power would dominate the second; i. e., it would cause the second to be so changed by the greater catalytic power of the first as to be capable of being taken into and finally incorporated with the substance of the latter, the latter possessing the more intensive anabolic processes. To state it in physiologic terms, the second mass would be digested and assimilated by the first. Herein, I believe, lies the key to the differentiation of living protoplasm into animal and vegetable forms. This "cannibalism," early established, was followed later by a lessened and finally by a loss of the power of the dominant form to construct its proteins and other constituents directly from the materials of the environment. Here, then, is a forward step of great importance in the progress of evolution. Herein also, I believe, lies the explanation of the disappearance of the intermediate and primitive bodies which preceded the appearance of fully developed protoplasm. In the "catalytic struggle" they failed to survive and under changing conditions have long since ceased to be formed.

The fact that in living protoplasm the building-up or anabolic processes immeasurably exceed the building-down or catabolic processes is of vast importance. As a result, living protoplasm has spread all over the earth; it has not only invaded sea, plain, valley and mountain, but has penetrated into every corner, nook and cranny of earth, water and air in which the conditions necessary to its chemical and catalytic interchanges exist. All lacunae are filled. Here is the explanation of its survival and persistence through such vast periods of geologic time. Further, living protoplasm is a plastic aggregate which has been able to adapt itself to the most varied environmental conditions. It certainly does not seem strange that it has assumed the most varied forms. I, myself, believe that in the marvellous catalytic power of the protoplasmic aggregate, that power in which the anabolic processes so greatly exceed the catabolic processes, lies the key to the explanation in a large measure of evolution.

Time will not permit of the application of this dynamic principle to the details of the evolution of animal and vegetable forms. One must be content here with the general conception that further and increasing differentiations are dependent, first, on the materials available in the environment and, second, on the innate catalytic power of the living protoplasm. Necessarily, under

given conditions, there ensued an increasing complexity of the chemical changes in the latter. In unicellular forms, as in the ameba, these changes remained relatively simple; not so, however, in the metazoa. Here one finds that each cell possesses not only the special structure that enables it to fulfil the functions of the tissue of which it is a part but also special ferments by means of which it builds itself up and adds to its own substance out of the general material of the blood plasma. Each cell possesses the power of taking in foreign materials, of fragmenting them, and of utilizing them for purposes of reconstruction or as sources of energy. In return, each cell gives up to the blood stream such substances as are of no further value to it. These substances, the products of its continued chemical changes, may consist in part of materials so far reduced that they are no longer sources of energy and are ready for discharge from the organism as waste materials, such as urea; or they may consist of substances which have, first, still a food or, second, a catalytic, value for the cells of other tissues. As an instance of the first may be mentioned the glycogen of the liver; as an instance of the second, the epinephrine of the suprarenals.

It is important to envisage continuously the organism as a whole and to bear in mind that all of the tissues of the organism play a rôle in its chemical changes; i. e., in its metabolism. What has been learned of the various glands of internal secretion as to their embryology and their morphology justifies the statement that certain glandular structures — perhaps like the thyroid early provided with a duct and serving at first certain ulterior purposes — became the seat of the formation of intensive catalysts serving certain special functions. Certain structures, most diverse in origin and probably serving other functions early in the evolution of the organism, became associated in the general and special metabolism of the organism. Thus the thyroid, the pituitary, the chromaffin system and the sympathetic nervous system became synergically related; they constitute a synergic group. While certain of these, like the thyroid and pituitary, came to influence especially growth and development, the skeleton and other structures, all of them came to act together to promote activity of the tissues; all of them increase metabolism; all of them promote catabolism and the release of energy. On the other hand, certain other structures have to do with the storing up of energy. The pancreas and, in fact, all the glands of the alimentary tract together with its adnexa are under the influence of that portion of the sympathetic nervous system spoken of as autonomic. They are all concerned in the processes of digestion and assimilation, in other words, in the storing up of energy. The thymus and parathyroid are both in synergic relation with the pancreas and must therefore be added to this group. All are opposed to the disintegration, to the downward change of the body constituents, in other words, to catabolism.

To repeat the facts in other words, the symbiosis of the cells in metazoa leads gradually to the differentiation of the glands of internal secretion. This meant, in an increasing degree, specializations of the catalytic processes of living protoplasm. This implied further, in a large measure, the specialization of chemical changes in the individual cells, as well as a mutual inhibition of the chemical processes in the organism in its entirety; and this is exactly what occurred.

Almost every one who has thought seriously on the subject of evolution and who has realized the truth, i. e., the fact of evolution, has attempted some explanation of its cause — has either framed some explanation to satisfy himself or has sought refuge in the explanations framed by some of the world's great thinkers. Two names, of course, stand forth in striking prominence, that of Lamarck and that of Darwin; the one deals with the rôle which the use of organs may have in their development; the second points out the rôle which nature plays in the struggle for existence and in the survival of the fittest, a fact which has been stated obversely as the death of the unfit. Both explanations lack a primal, driving cause inherent in the living organism itself. Both enter into the explanation of results but not as to origins. Bergson

(Creative Evolution, translated by Arthur Mitchell, Ph.D., 1911), feeling the necessity of a special cause, used the expression the "vital impetus" (élan vital); this, however, merely assumes a fact without offering an explanation as to the origin of the fact; Eldridge used the term "organizatory factors" (The Organization of Life, 1925) which equally fails to explain, while the Italian physiologist, Giulio Fano, satisfied himself with the expression the "cosmic will." For me the term, the "cosmic will" — and I say this with all courtesy — has nothing but the vaguest significance. Like the other terms, it does not give any help in the solution of the problem which evolution presents.

Is the conception of a dynamic factor of any value in the solution of this problem? Of the existence of such a dynamic factor there can be no doubt. The enormous catalytic, constructive power of living protoplasm is one of nature's outstanding facts. Obviously, it must be admitted into our problem. Is it of itself sufficient to explain the differentiations and increasing complexities of organisms? I believe that it is. I believe that, taken in connection with certain other factors which likewise have to do with the reaction of the organism to the environment, it is the one outstanding cause of evolution. The metabolism of the metazoa, complex as this is in the higher forms, cannot be a fixed, an unchanging metabolism. The metabolism of the organism must, of course, within certain limits, vary with its environment. The cells of the various tissues of the metazoa have the power of appropriating and assimilating certain materials from the blood plasma, but clearly in the exercise of this function they are dependent on the materials presented by the blood plasma. The blood plasma in turn must build itself up out of such materials as come to hand and are ingested by the animal. It follows that if given variations in the environment occur, e. g., in the food, these variations must affect the constitution of the blood plasma, and thus the metabolism of the entire organism. From such evidence as presents itself it is safe to infer that, in the past, variations in the environment, food, character of medium, water or air, temperature and other climatic conditions, took place slowly and allowed of adaptations of the organism to these gradually changing conditions. It can readily be comprehended that such a modified metabolism could be transmitted to the offspring for it would be a general character, one affecting the organism as a whole. Indeed, the question of the heredity of such a modified metabolism need not be considered, if one reflects that the young offspring would necessarily be submitted to the same modified environment and would biochemically adapt themselves to it just as had their predecessors, perhaps even more readily, because the young are relatively more plastic. With this interpretation in mind, one may admit and dispense with the discontinuity of variations so much insisted on by Bateson, for the reason that spontaneous variations, so-called, are really not a part of the problem. Further, it would appear that increasing complexity and differentiation in response to environmental change can go on almost indefinitely so long as previous adaptations to the environment have not imposed on the organism such fixations or limitations of structure as to make further adaptations to changing conditions impossible. And yet the existence of such highly modified mammals as the seals and cetaceans, the manatee and the dugong, not to speak of that marvellous aquatic reptile of bygone days, the ichthyosaurus, show how much adaptation is possible even in forms already highly differentiated. Probably one should admit here the play of the theory of Lamarck, bearing in mind that the use or overuse of an organ must in its turn react on the metabolism of the animal and doubtless in many cases react directly on given glands of internal secretion. When one reflects again on the rôle of the pituitary and thyroid in growth and skeletal development, the facts become more than suggestive. Suggestive, too, are such facts as the appearance and disappearance of the notochord in ascidians. It would seem that the to and fro movements of the young in swimming would lead spontaneously to the deposit of gelatinous or other fixative materials in the only portion of the organism relatively at rest and capable of furnishing a point of fixation for muscular action; while in the

subsequent sessile condition, the notochord thus formed would again spontaneously disappear from nonuse. Lamarckism should, I believe, be given its due weight. This is true also, of course, of the great static, inhibiting principle enunciated by Darwin. Each has its rôle to play in interpretation. Professor Jennings, of Johns Hopkins University, lays great stress on the influence of changed conditions of the environment and, in his book "Prometheus," uses among other things as an illustration the well-known facts of the transition of the aquatic form of axolotl to a terrestrial form (Prometheus or Biology and the Advancement of Man, New York, E. P. Dutton & Co., 1925, pp. 45 to 47).

I am not presenting here a theory of evolution. I am merely calling attention to a dynamic, driving principle inherent in living matter. Further, the increase in mass leads to a division of the mass, i. e., to multiplication or reproduction. I believe that the same factors enter into this division whether the division is expressed by simple fission or by the more complex process of mitosis; namely, by the interactions, catalytic and chemical, of the contained colloids and crystalloids. Conjugation and sex differentiation also find an explanation here, an explanation already hinted at in the view presented earlier in explanation of the differentiation of animal and vegetable forms. The problems of heredity follow a similar course. The conceptions here presented suggest, among other things, the daring thought that the theory of genes is unnecessary. The chromosomes are aggregates of amino-acids or proteins which are the seat of continuous and progressive catalytic and chemical changes. They can react only with the other cell contents and with each other, in certain definite ways. The changes which take place are necessarily consecutive. They give rise, finally, in the offspring, to certain resultant qualities which are the same or similar to those presented by the parent form. This view seems to me preferable to one that assumes the existence in the chromosomes of thousands of minute chemical parcels which contain the materials necessary for the transmission of the various hereditary qualities. In keeping with this thought, Professor Jennings expresses himself as follows: "The characteristics of the adult are no more present in the germ cells than are those of an automobile in the metallic ores out of which it is ultimately manufactured" (Prometheus or Biology and the Advancement of Man, p. 28).

Explanation of the Lantern Views Illustrating the Papers of Drs. Mills and Dercum. Dr. Charles K. Mills.

A few pictures were shown which assisted in illustrating the points of view which have led to the adoption of the theory of a multiple primate ancestry for the human race. It will be recalled that Dr. Mills described the appearances and departures from the standard or normal human brain of the brains of criminals, imbeciles, paranoiacs and also the brains of the negro, the Chinaman and different types of European people.

Figure 1 shows the brains of primates from the lemur to man arranged in phyletic series from Edward Anthony Spitzka's book "A Study of the Brains of Six Eminent Scientists and Scholars belonging to the American Anthropometric Society," etc.

One extremely good photographic representation was shown of a negro brain, viewed from above, taken from Parker's work on the "Morphology of the Cerebral Convolutions with Special Reference to the Order of Primates."

On the screen two views of the brain of a Chinaman were also shown, the case being one reported jointly by Dr. Parker and Dr. Mills. This brain had some features not usually found in the Caucasian human brain. In both the right and the left hemisphere of this brain, bridging convolutions occurred in the calcarine region, a condition not usually found in the white race. In man, as Parker pointed out, the occipital lobe reaches its highest development, as it is also the last to develop completely.

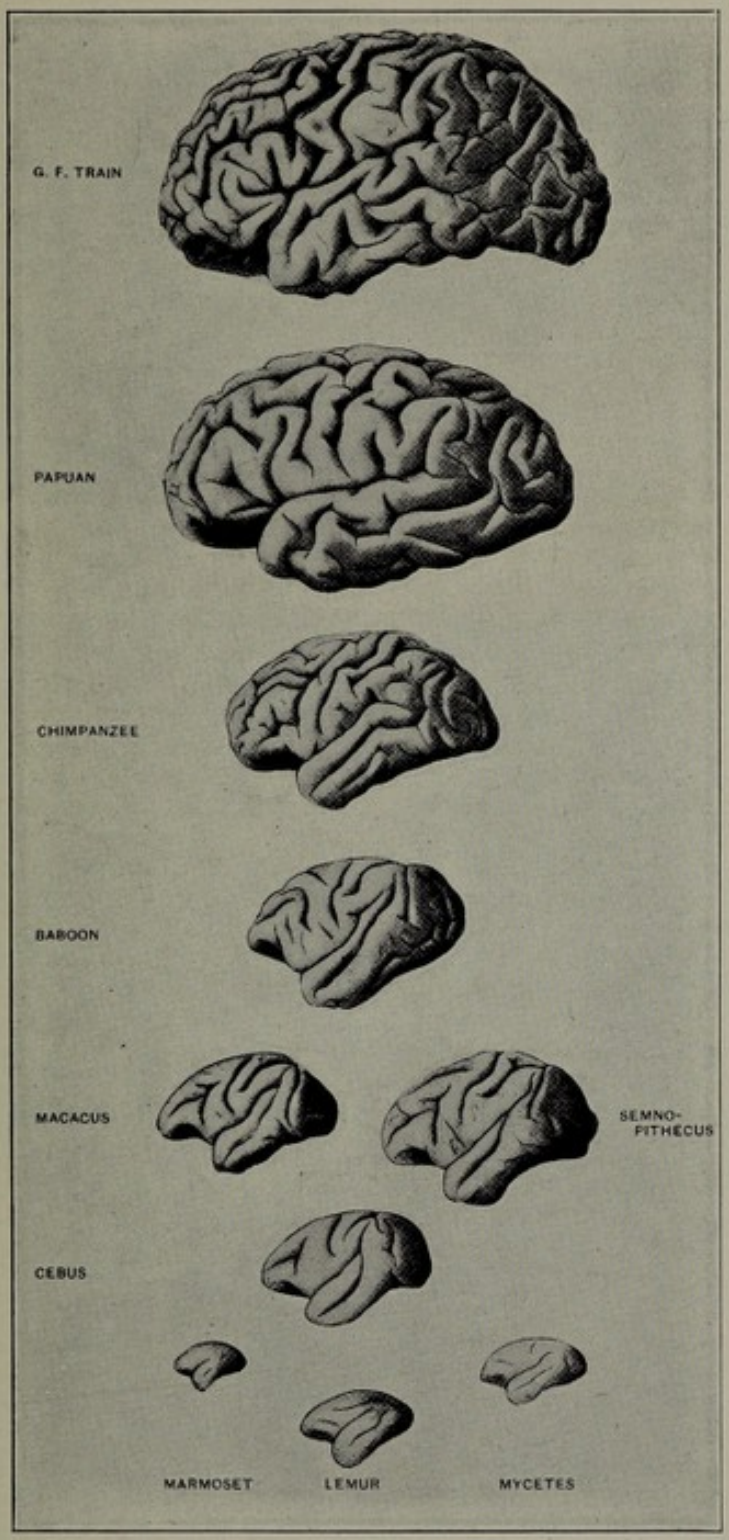

Fig. 1.—Brains of primates from the lemur to man arranged in phyletic series. Taken from "A Study of the Brains of Six Eminent Scientists and Scholars Belonging to the American Anthropometric Society" by Spitzka.

Fig. 2.—Darwin's home, Downe House, in Kent.

Fig. 3.—Photograph of Charles Darwin.

Two pictures were shown of the brain of a confirmed murderer and criminal, Joseph Taylor. The brain showed many simian appearances and reversions.

The next picture, taken from Spitzka, was a dorsal view of the brain of Gauss, the mathematician. This showed great fulness and complexity of the fissures and convolutions.

The two illustrations show the lateral and mesial aspects of the brain of Joseph Leidy, from Spitzka's book. Even a casual study of these pictures show how the brain of Leidy, like that of Gauss, differs in its surface morphology from the racial and low type brains just described.

The third illustration gives a view of Darwin's home "Downe House" (fig. 2) in Kent, England, and a photograph of Charles Darwin (fig. 3) taken from "The Life and Letters of Charles Darwin" by his son, Francis Darwin.

Suggestions to Make the Home of Darwin a National Shrine.

In his presidential address at Leeds, Aug. 31, 1927, Sir Arthur Keith made an appeal for a fund to purchase Darwin's home at Downe in Kent, so that it might be preserved for the nation. Mr. George B. Browne, a retired surgeon, on reading the appeal at once telegraphed to Sir Arthur, offering to make himself wholly responsible for the gift. The cost, with some endowment fund, is estimated at from $60,000 to $75,000. Mr. Browne made it a condition that no other contributor is to be asked to share the cost with him.

Mr. Browne was admitted to the membership of the College of Surgeons in 1874, and for fourteen years acted as assistant to Sir Henry Thompson. He is an antiquarian and an enthusiastic collector.

In offering to buy Downe House and to establish a fund for its perpetual upkeep, Mr. Browne is giving expression to his profound admiration for the work of the great naturalist. He considers that the house in which evolution was cradled should be as reverently preserved as Shakespeare's birthplace. He desires that the house should be restored as nearly as possible to its condition when Darwin lived there. When the house and garden have been restored, Mr. Browne wishes them to be opened without charge, to visitors who could then be shown Darwin's study, laboratory and living-rooms much as when he left them. He also expressed the wish that some physician of slender means and good record should be appointed the custodian.

Sir Arthur Keith has suggested that out of the endowment fund, money should be spared for a prize to be given every second year for the best contribution to biologic knowledge. Downe House is the property of Darwin's son, Prof. Francis Darwin, and is now a school.

Lantern Slide Demonstration of a Series of Primate Brains. Dr. William B. Cadwalader.

Sir Arthur Keith, in a lecture given at Manchester, England, in August, 1927 (*Brit. M. J.* **2**:441 [Sept. 10] 1927), quoted Prof. Elliot Smith, who summarized the results of his extensive anatomic studies as follows: "No structure found in the brain of an ape is lacking in the human brain, and, on the other hand, the human brain reveals no formation *of any sort* that is not present in the brain of the gorilla or chimpanzee. The only distinctive feature of the human brain is a quantitative one."

It is generally agreed that the brain of an anthropoid ape is surprisingly similar to that of man. In all apes each cerebral hemisphere (fig. 1) is divided into the same lobes as in man; that is to say, frontal, parietal, occipital and temporal. The cerebrum does not completely cover the cerebellum. The frontal and parietal lobes are separated by the central fissure. The arrangements of the motor centers is the same as that in man. This has been demonstrated experimentally by Sherrington and Grünbaum.

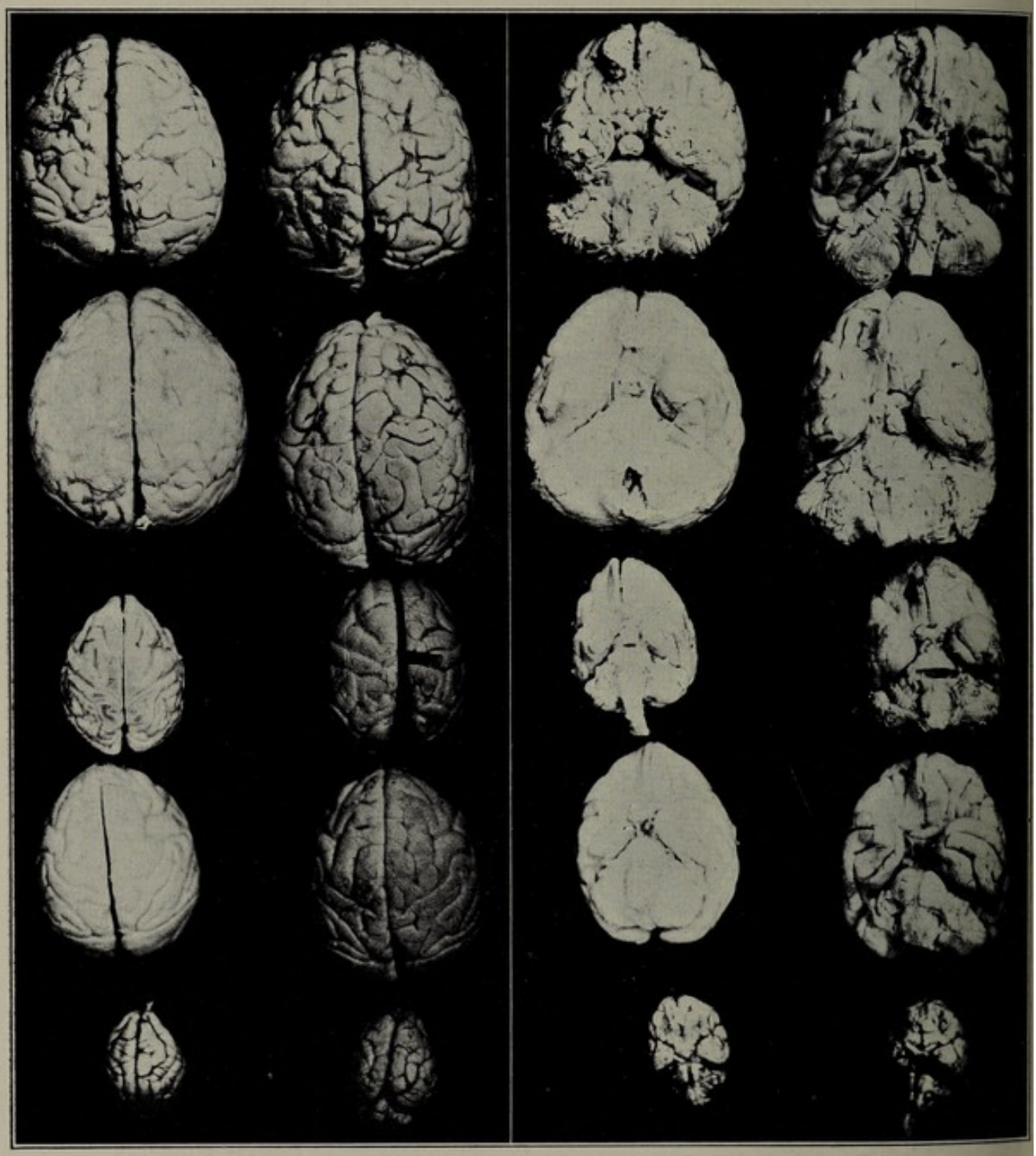

Figure 1 Figure 2

Fig. 1.—Superior view of brains of primates, ranging in size from that of a chimpanzee to that of a lemur.

Fig. 2.—Inferior view of same brains shown in figure 1.

The sylvian fissure is complete (fig. 2) only in man when the anterior and posterior limbs are present. In apes, the anterior may be absent and the posterior may be bifid. Apes have a simian "sulcus" or "Affenspalte" which sweeps across the hemispheres and lies behind the parieto-occipital sulcus, or may pass into it. In man, the small sulcus lunatus corresponds to the Affenspalte.

The following summary is given by Sonntag (Morphology and Evolution of Apes and Man, p. 278): The human brain differs from that of apes in the following ways: (1) it is larger both absolutely and relatively to the size of the body; (2) the neopallium is larger and the association areas are more complex; (3) the parietal and frontal lobes are more voluminous; (4) the sylvian fissure is complete and the insula is concealed; (5) there are calcarine and retrocalcarine sulci; (6) the small sulcus lunatus corresponds to the large Affenspalte; (7) secondary sulci are more numerous; (8) the cerebrum conceals the cerebellum more completely, and the latter shows a higher phase of evolution; (9) many greater complexities are the result of a large neopallium; (10) some of the cranial nerves are smaller; (11) the corpus callosum is larger.

A lantern demonstration was given of the brains of the following primates, as shown in figures 1 and 2, superior and inferior views, from above downward in the order shown in the accompanying table.

Weights of Animals and of Their Brains Shown in Figures 1 and 2

	Weight of Animal (Kg.)	Weight of Brain (Gm.)
Chimpanzee (*Pan niger*)	56.8	300
Chimpanzee (*Pan niger*)	32.7	430
Orang (*Simia satyrus*)	18.6	400
Orang (*Simia satyrus*)	19.5	350
Hainan gibbon (*Hylobates hainanus*)	6.0	115
Silver gibbon (*Hylobates leuciscus*)	3.03	75
Rhodesian baboon (*Papio rhodesia*)	8.0	220
Guinea baboon (*Papio sphinx*)	6.8	180
Black and white lemur (*Lemur varius*)	2.5	24
Ring-tailed lemur (*Lemur catta*)	1.7	30

A slide which had been made from an illustration (fig. 3) in Sir Arthur Keith's book (The Antiquity of Man, vol. 2, p. 612) was shown, illustrating a preparation of the reconstruction of the brain of the Gibraltar man, the name given to one of the prehistoric skulls of the Neanderthal race, which he believed belonged to a man that had existed in the pleistocene geologic period, computed by him to have dated somewhere between 100,000 and 200,000 B. C. Sir Arthur Keith selected this particular skull from a collection because he thought it represented one of the smallest of any of that race, and for this and other reasons he believed it more nearly approached the anthropoid type. Superimposed on the outline of this brain is placed the brain of a young gorilla, the ape believed to be nearest to man. The diagram shows distinctly the great expansion of the reconstructed Gibraltar brain, its comparison to the brain of the gorilla, in parietal and frontal regions; and it shows most especially the development of the inferior frontal convolution in the human type, with the corresponding lack of development of this portion of the frontal lobe in the brain of the gorilla. Such differences have been emphasized from time to time by different authorities, and have been used as an argument to explain the absence of the function of speech in apes. This lack of function of speech in turn has been regarded as a factor in explaining the enormous psychologic gulf that exists between man and apes.

If one classifies man by strict zoologic methods, as seems justified, then he must be placed in the order of primates together with the others of this order. But it should not be forgotten that zoologic classification is based on strict comparison of anatomic structures. It does not make any allowance whatever for the enormous psychologic differences existing between the highest and lower primates.

DISCUSSION OF PAPERS PRESENTED BY DRS. DERCUM AND MILLS

Dr. J. Hendrie Lloyd: Dr. Mills' paper contained many suggestive ideas, but the one that interested me most was the suggestion of the multiple origin of the human race. This had once been held to be a sort of heresy by certain evolutionists. Their idea was that the human race was all of one stock, descended, as it were, from a single root and represented in a common ancestry. Their favorite illustration was a genealogic tree, showing diagrammatically the roots fixed in the eocene lemnes, then the trunk ascending and giving off branches, first of the anthropoids, then successively of the various

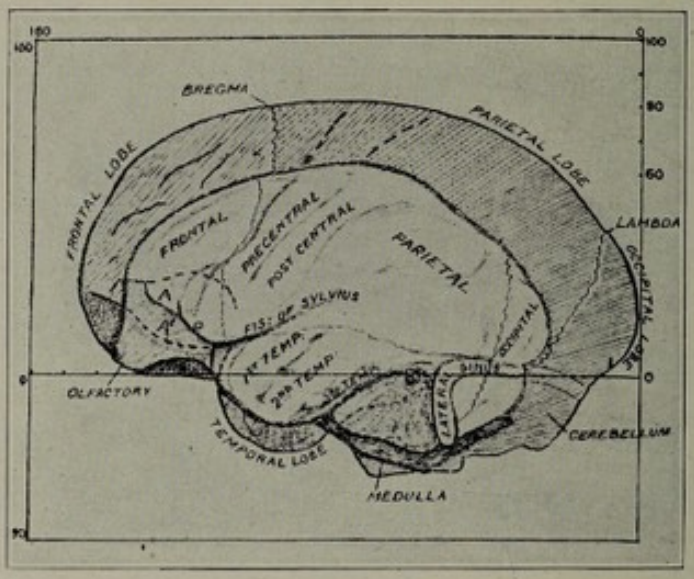

Fig. 3.—Profile drawing of the cast of the brain from the skull of a young gorilla superimposed on a corresponding drawing of the cast from the Gibraltar skull. The Gibraltar cast exceeds that of the gorilla in all dimensions. From "The Antiquity of Man," by Sir Arthur Keith.

kinds of men, until at the very top was seated *Homo sapiens* or modern man. The objection to such a scheme is that it sidetracks all lower forms of primates and tends to deny that they are in the line of human ancestors. This is clearly shown in such recent works as those of Keith and McCurdy. This school of evolutionists seem unwilling to recognize any transitional types as they are found, although this is the very thing that the doctrine of evolution requires. When, for instance, the Piltdown man was discovered, one anthropologist objected to the shape of the lower jaw, and on this slender basis denied that the Piltdown man could be a human ancestor. The lower jaw was too simian, although the upper part of the skull was much better. To an unprejudiced observer this looks like a good transitional form, combining both human and anthropoid characteristics, and so thought Elliot Smith, if I remember correctly.

The doctrine of a single human stock might almost be called the Garden of Eden theory. It requires one to believe that the human race has been evolved from some one spot on the earth's surface, although just where that

spot was no one can tell. Only recently an expedition went to the interior of Asia to find the original home of the race, but it brought back only a dinosaur's egg. Griffith Taylor also believed the race took origin in Central Asia, and thence spread by successive "waves" over the earth, beginning with the negritos, like a volcano erupting successive streams of lava. In fact, Taylor called it the "Lava Flow" theory. It is such fantasies that tend to bring the doctrine of evolution into disrepute.

McCurdy said that the stem took root at the beginning of the tertiary period (eocene) in North America. These early lemurs resemble lemurs still living in the Malay Archipelago; but he quoted Matthews who believes the center of lemur dispersal to have been in Asia north of the Himalaya Mountains. Cope believed that the *Anaptomorphus* was the common ancestor of apes and men; it is found in the eocene period of North America; another thought the earliest were the lemuroids of Western Europe. How are all these conflicting data and opposing views to be reconciled with the doctrine that the human race is of only one stock? It would seem more in accord with the evidence to suppose with Dr. Mills that there has been more than one stock. This was also Klaatsche's idea, who believed in at least two distinct origins of man—one in Africa, which included the gorilla and Neanderthal man, and the other in Asia, including the orang and possibly some modern men. But if there were two, why not more than two? The processes of evolution have been going on everywhere and are not limited to one region. Like causes produce like effects.

Keith believed that the Neanderthals, who lived until a comparatively recent day, were a distinct genus, not closely related to *Homo sapiens*. Perhaps they were not related at all. On the other hand, Hrdlika maintained recently that the Neanderthals were in the direct ancestry of modern man. Thus opinions differ.

Dr. Dercum's paper seems to reflect a tendency that has been apparent for sometime among evolutionists. It is a movement away from descriptive morphology toward the domain of physicochemistry. Osborn, for instance, dissatisfied with Darwinism, tried to evolve a theory to account for variation. This question was avoided by Darwin, Huxley and the older evolutionists. Darwin simply accepted the facts of variation and built his doctrine on those facts. He expressly disclaimed any knowledge of laws and processes underlying those facts. The more recent schools concern themselves with the more occult problems of organic matter. They believe there is some force or energy which impels and controls organic matter in processes of evolution. They use such terms as "internal urge," and the "élan vital" of Bergson. These are obscure terms to explain this organic force in terms of physicochemistry.

Osborn said: "Germ evolution is the most incomprehensible phenomenon which has yet been discovered in the universe." This opinion will probably be shared by most reflecting men. Take, for instance, the embryo. The embryo develops an eye which has never seen the light, a stomach which has never digested food, limbs which have never walked, lungs which have never breathed. All this is certainly not to be explained by any law of the adaptation of the organism to the environment. It is due to an inherent, mysterious, unknown power in the germ plasm. Osborn's statement is not an exaggeration; this is the most incomprehensible problem which nature has set before us. Whether it will ever be solved is a question.

Dr. J. Parsons Schaeffer: I want to assure Dr. Mills and Dr. Dercum that I have never been offended by the doctrine of evolution; rather I have thought of it as a noble way of bringing man to his present estate. So far as scientific facts can be brought to bear on man's history, they point in the direction of man's evolution from a more lowly form or forms rather than his appearance by a special act of creation. While there may be differences of opinion as to details, there appears little doubt on the more basic problems involved.

Dr. Dercum's second paper has to do with the "beginnings of things." One cannot help but recall the statement of Smuts in this connection, which is worthy of thoughtful reading: "The acceptance of Evolution as a fact, the origin of life-structures from the inorganic, must mean a complete revolution in our idea of matter. If matter holds the promise and potency of life and mind it is no longer the old matter of physical materialists. We have accepted Evolution but have failed to make the fundamental readjustment in our views which that acceptance involves. The old mechanical view-points persist and Natural Selection itself has come to be looked upon as a mere mechanical factor. But this is wrong. Sexual Selection is admittedly a psychical factor and even Natural Selection has merely the appearance of a mechanical process, because it is viewed as a statistical average from which the real character of struggle among the living has been eliminated.

"Nineteenth century science went wrong mostly because of the hard and narrow concept of causation which dominated it. It was a fixed dogma that there could be no more in the effect than there was in the cause; hence creativeness and real progress became impossible."

Reference has been made to Sir Arthur Keith. In his Leeds address (1927), Sir Arthur pointedly stated that Darwin was and still is right, that man under the action of biologic forces which can be observed and measured has been raised from a place among anthropoid apes to that which he now occupies.

I am not certain, as someone has suggested, that Keith is committed to the "one line" origin of man. In the address referred to, Keith, among other things, said: "Our older and discarded conception of man's transformation was depicted in that well known diagram which showed a single file of skeletons, the gibbon at one end and man at the other . . . . We should never have made this initial mistake if we had remembered that the guide to the world of the past is the world of the present. In our time man is represented not by one, but by many and diverse races . . . To unravel man's pedigree, we have to thread our way, not along the links of a chain, but through the meshes of a complicated network."

This does not appear to oppose the thought of a multiple primate ancestry for man.

Reference has also been made to Professor Osborn, who has brought profound knowledge, insight and industry to bear on the problems of the evening. I fear he is misunderstood. It is not that Osborn does not believe in the evolution of man from lower forms, but he has come to the conclusion that apes have no close physical and mental kinship with man. He considers the idea of man's ape ancestry faulty, and this largely due to our previous ignorance of the real course of human evolution.

Osborn, citing Gregory (*Science*, vol. 65), arrived at the following striking conclusions: 1. The human family, like other families, includes a great number of independently evolving phyla which for untold ages evolved independently of each other in different parts of the world. 2. As in other mammals, one shall rarely find the true stem forms at the bottom of the phyletic lines. 3. The older of these human phyletic lines may well run back as far as many other lines of mammals do, that is, at least to the Lower Oligocene or Eocene. Hence even in those inconceivably remote ages one may expect to find Dawn men — erect-walking, plains-living, large-brained, speaking men, totally dissociated from the family of the apes, especially in their evolutionary trend which was toward life in the open, while that of the apes was toward more and more specialized life in the trees. 4. Hence the idea of man's ape ancestry is a myth and a bogie, due to the previous ignorance of the real course of human evolution. For millions of years man has been a ground-living, erect-walking being and if at some still earlier period he may have passed through an arboreal stage, such a stage could not have been long or have left a deep imprint on his skeleton and nervous system.

Gregory regretted that he could not follow his "honored leader into the new and spacious field of thought" and deemed it his "duty to defend the old and always unpopular view of Darwin, Huxley, Haeckel and others of previous generations." He said: "In conclusion then, during the past twenty years I have published a series of investigations on the classification and evolution of the vertebrates, dealing since 1916 especially with the origin of man, and during this period I have been unable to discover a single valid objection to the direct evidence afforded by comparative anatomy and in harmony with the paleontological record of the entire Primate order, so far as known, namely, that man's relatively close kinship with the chimpanzee and the gorilla is an unassailable fact. . . .

"Refusing to accept even the paleontological record so far as it is known, disregarding the cogent and direct evidence of comparative anatomy, many paleontologists do not hesitate to extend to man supposed laws of evolution deduced from the study of orders of mammals which in their entire organization and history stand in wide contrast to the primates. From such analogies has been conjured the Eocene Dawn Man — a colossal anachronism some forty million years ahead of his time in the world's history."

Osborn and his pupil Gregory, therefore, appeared to be at the opposite ends of the log. They sighted "the same vastly distant and obscure event, the emergence of man, from somewhat different view-points," and "naturally report somewhat different aspects of it." As Dr. Lloyd put it, "What are we to believe?" Maybe Professor Osborn hopes to pacify a hostile public, for, in the language of Gregory, "in this way sensitive souls may be able to hear the word 'gorilla' without shuddering." However, it should be stated that many who have studied mammalian phyla are in more or less accord with Osborn. Others, like Gregory, disagree.

In a recent address in America, the Lord Bishop of London (Winnington-Ingram) came to the support of science by saying: "Scientists cannot discover too much because no truth can contradict itself." However, to establish truth is not always an easy matter, and to evaluate observed facts properly is equally difficult. One has clearly to do with observations and evaluations. Doubtless, the personal equation enters into the latter to a greater degree than into the former in bringing about varied conclusions.

Mention has been made of Owen. I have always admired this great comparative anatomist. One must not forget the time at which he lived. Then one will be less harsh in criticism of him. Owen believed that the differences between man and ape are so diverse that it is necessary to list mankind in a separate and distinct order in the animal kingdom. In this he erred and had to yield ground to Huxley. Engaged in the controversy one finds Hooker, Russell, Darwin, the Bishop of Oxford and others.

The decisive chapters in Darwin's "Descent of Man" are those which have to do with the evolution, anatomy and function of man's brain. As is well known, Darwin was not a professional anatomist, and he accepted Huxley's views "that there was no structure in the human brain that was not already present in that of the anthropoid." Recently (1927), Prof. G. Elliot Smith, in a notable research, concluded as follows: "No structure found in the brain of an ape is lacking in the human brain, and, on the other hand, the human brain reveals no formation of any sort that is not present in the brain of the gorilla or chimpanzee. . . . The only distinctive feature of the human brain is a quantitative one." Quality is sometimes mentioned as a distinguishing feature; however, probably one never will be able to evaluate the imponderable quality.

The following would appear to be newer and yet fruitful fields for the investigation of man's kinship. Some of the fields have been worked, yet in no instance has the harvest been fully gleaned: (*a*) Histologic investigation of a specific cell or specific areas of the brain in a large number of brains from men and women of various degrees of intelligence and the anthropoids and higher mammals. (*b*) A study of the associational and commissural path-

ways, having in mind size and volume. (*c*) A comparative study of both the brain cortex and the commissural and associational pathways of the amount of supporting tissue (neuroglia) as compared with neurons. (*d*) A study of myelinization in macrocephaly and microcephaly, in the brains of scholars and of the illiterate, and in the brains of the higher mammals. (*e*) The effect of stimulation on the growth of centers and on the myelination of nerve pathways. (*f*) A study of the critical developmental periods of the brain, as has been done in other regions of the body.

To show how anatomic, phylogenetic and clinical studies on the central nervous system may be a factor in determining man's kinship, I wish to refer to the work of Dr. Brouwer. Degenerations resulting from localized experimental lesions in the retina of rabbits, cats and monkeys were studied by Marchi's method. The course and distribution of fibers from the retinal quadrants and the macula were charted. The arrangements were found to differ widely in the three animals, and the "monkey so closely resembled man that the pattern there revealed can probably be employed with little change in the analysis of clinical (human) cases."

It appears to me that the experimental method is an additional way of approaching the problem of man's kinship. Heretofore, the approach has largely been geologic and paleontologic and one of morphologic comparisons. Brouwer's work showed the value of experimentation. Again, take the problem of myelination. Born prematurely at the end of the seventh month, a child will be much advanced, so far as myelination of the fibers of the so-called optic nerve is concerned, over a baby that is held in utero to the end of the ninth lunar month. Here one has the factor of stimulation and in a sense the influence of environment on myelinization. One would like to know whether like environment would result in the same degree of myelinization in a series of experimental animals including the anthropoids and man. Time forbids reference to more phases of the experimental method.

In conclusion, I wish to refer to the critical and meaty book of Herrick, "Brains of Rats and Men." It is well known that there are great gaps in the knowlege of matter, life and mind. They appear unlike each other; yet they are all three in human experience. Herrick found fault with many of the preachments of psychologists, and rightly so. He said, "to the biologist, most of this newest psychology seems like very orthodox physiology." Also, "Consciousness is no more a nonphysical entity than is muscular contraction or any other bodily function, and the fact that it is a different sort of a function which has in the past been submerged in obscurantism should not blind our eyes to the scientific evidence that it is a natural, not a mystical process."

Another suggestive statement from Herrick reads as follows: "Somewhere in the history of primate evolution, during the course of progressive elaboration of the apparatus of cortical associations, sufficient complexity of tissue and plasticity or organization was attained to facilitate rapid learning, the retention of memories of single experiences and the abstraction from these of certain features common to all of them and finally the integration of these common features into symbolic patterns. Symbolic thinking is a new kind of function, though the steps by which it was fashioned can probably be traced, just as we have already succeeded in charting in outline the progressive elaboration of the neurologic mechanisms employed." This suggests the charting of the evolution of symbolic thinking.

Herrick concluded by saying, "The first point which I wish to stress in this connection is that mankind has grown up; we have not merely enlarged and complicated the behavior patterns of rats and monkeys; we have improved upon them and added new patterns not elsewhere known." In other words, Herrick would have it understood that men are bigger and better than rats and monkeys. This conclusion, I believe, is scientifically correct, and to the general public it is much more satisfying.