Hunterian Lectures
ON
MAN'S POSTURE: ITS EVOLUTION AND DISORDERS.

GIVEN AT THE ROYAL COLLEGE OF SURGEONS OF ENGLAND
BY
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[*Abstracts.*]

LECTURE I.—THEORIES CONCERNING THE EVOLUTION OF MAN'S POSTURE.

THE true story of how anatomists abandoned the belief that man's body was a special creation and became converted to the theory of evolution commences in 1809, the year of Darwin's birth—when England and France were striving for mastery in the Spanish peninsula. The new idea was born in Paris—not, as one might well expect, in the famous schools of human anatomy hid amongst the crowded streets on the south bank of the Seine, but in the Museum of Natural History, situated in the neighbouring Jardin des Plantes. Three officials of the Museum—Cuvier, the Professor of Comparative Anatomy, Geoffroy St. Hilaire, who had charge of the collection of Vertebrate animals, and Lamarck, who was responsible for the Invertebrata—were effecting, amidst war and political change, a complete revolution in man's conception of the animal kingdom.

In 1809 the magnificent Cuvier, then in his fortieth year, standing, so far as concerned the public eye, head and shoulders above his colleagues, was bringing together the material for his famous work on *Ossements Fossiles*, awakening men to the knowledge that boundless ages of teeming life had come and gone before the present era began. While Cuvier was thus unconsciously enlarging man's conception of the past, his colleague, Geoffroy St. Hilaire, somewhat Cuvier's junior in years, was seeking for the common plan or design on which the bodies of vertebrate animals were built, thus preparing the way for those who were to preach the doctrine of a common descent for all living things. Lamarck, the least favoured of the three in the estimation of the learned men of his time, was twenty-five years Cuvier's senior. In the hustings of contemporary science he could scarcely make his voice heard, but we now know he had probed deeper into the secrets of Nature than either of his two colleagues. All his life long he had been a retiring but systematic student of living things and of the conditions under which they live. He was already an old man—a man of 65—when in 1809 he published two small volumes under the title of *Philosophie Zoologique*, in which we see that this retiring pioneer, as a result of a half-century of patient study, had reached the conviction that all the living things to be found on the earth to-day were but the twigs of a common tree of life, whose branches, trunk, and root were buried deeply in the past ages of the world. It is in this work, written in the seclusion of the precincts of the Museum, away from dissecting-rooms, and during stirring years of war, that we find the first clear statement of the belief—now universally held by human anatomists—that man's posture of body has been evolved from one which was simian or ape-like.

LAMARCK'S THEORY.

To do Lamarck full justice it would be necessary to make lengthy extracts from those chapters which deal with the evolution of man, but the following quotation (vol. i, p. 349) will give a just estimate of the manner in which he explained the evolution of man's posture:

"Indeed, if any race of primates (quadrumanes) whatsoever, particularly the more highly evolved of them, were to lose, either from force of circumstances or any other cause, the aptitude for tree climbing and of grasping the branches with their feet, as with their hands, for security of grip; and if the individuals of this race, for a series of generations, be obliged to use their feet only in walking, and cease using their hands as feet; then there is no doubt, from the evidence produced in the foregoing chapters, that these apes would finally be transformed into man (bimanes) and that the great toe would no longer be separated from the other toes like a thumb, the feet serving merely the purposes of progression."

From this passage we see that, in the first place, Lamarck supposed man to have been evolved from a chimpanzee-like anthropoid, for we know that of modern and living anthropoids he regarded the chimpanzee as "the more highly evolved." The gorilla, it may be mentioned here, was not discovered until 1847—eighteen years after Lamarck had been laid in his grave. In the second place we note that Lamarck regarded the erect posture as a result of the chimpanzee-like ancestor having abandoned an arboreal mode of life for one in the open country. In the third place we note that he held the belief—one which we still regard as unproven—that the progress made by one generation in accommodating itself to an erect posture would, age upon age, be transmitted to the next generation. He was fully alive to the fact that any anthropoid which had acquired the human mode of progression had gained an enormous advantage; it would no longer be confined to tracts of tropical jungle but would have the whole length and breadth of the earth open to it.

DARWIN'S THEORY.

Lamarck was a pioneer, but so far as concerns the evolution of man he did not induce a single anatomist of his own or of a succeeding generation to follow in his footsteps. We have to pass to the year 1871, when the *Descent of Man* was published, to find the first effective step in the development of our modern knowledge of man's evolution. The Philosophy of Zoology had remained sixty-three years in neglect, and Charles Darwin, who declared he had read and studied the book to no profit, was then 62 years of age. We turn at once to the *Descent of Man* to see what conception Darwin had formed concerning the evolution of the human posture. At page 76 of the first edition the following passage occurs, which contains an explicit statement of Darwin's explanation:

"As soon as some ancient member (elsewhere defined as some species of anthropoid like the chimpanzee) in the great series of the Primates came to be less arboreal, owing to a change in its manner of procuring subsistence, or to a change in the surrounding conditions, its habitual manner of progression would have been modified, and thus it would be rendered more strictly quadrupedal or bipedal. . . . 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. . . . As the progenitors of man became more and more erect, with their hands and arms more and more modified for prehension and other purposes, with their feet and legs at the same time transformed for firm support and progression, endless other changes in structure would have become necessary. The pelvis would have to be broadened, the spine peculiarly curved, and the head fixed in an altered position, all which changes have been attained by man. . . . It is very difficult to decide how far these modifications are the result of *natural selection* and how far of *the inherited effects* of the increased use of certain parts, or of the action of one part on another. No doubt these means of change often co-operate."

When the explanations advanced by Lamarck and by Darwin are compared it is at once seen that, as regards the manner in which the human posture has been evolved, there is much in common. (1) Both supposed that man had been evolved from a chimpanzee-like anthropoid and in the course of evolution the anthropoid posture had become human. (2) Both agree that the transformation had been initiated by a change from an arboreal to a terrestrial mode of existence. (3) Both believed that the results of habit or of function, acquired by one generation, could be inherited by the next generation. Darwin, however, made important additions: (1) he applied the law of natural selection—the tendency for successful individuals to survive and prosper; (2) he recognized the action of sexual selection; (3) he perceived that there was a law of correlation of parts—an obscure mechanism by which a number of structures were modified together to suit some particular function of the body. We now realize—or rather begin to realize—that the development and modification of various systems of structures are regulated or influenced by various internal secretions or "hormones." Darwin's law of correlationship of parts is but an intelligent anticipation of the more recent discoveries of physiology. We expect that fuller knowledge will yield the key to many problems in the evolution of posture which are at present unexplained.

In their bald outlines the explanations given by Lamarck and by Darwin of how man came by his erect posture have much in common. Why was it that for sixty-two years the one was regarded as an idle curiosity, while in the course of ten short and strenuous years the other had spread into every anatomical workroom throughout the civilized world, revolutionizing the worker's point of view and endowing his labour with a new aim and a new zeal? Both *Philosophie Zoologique* and *Descent of Man* were founded on a lifetime of inquiry and observation, but Darwin conquered—as men always will conquer—because he permitted a masterly array of facts to tell their own story, while Lamarck always wished

to tell the story of his facts. However that may be, there is no doubt of the fact that the *Descent of Man* is the starting point of our modern knowledge of all that pertains to the origin and evolution of the human body. The student of history will also note the fact that neither Lamarck nor Darwin was a professional anatomist, and yet they did more to alter our conception of the human body than any professional anatomist of their time.

How the Theory Now Stands.

Much has happened in the fifty-two laborious years which followed the publication of the *Descent of Man*. The time has come, so it seems to me, for a fresh survey of our knowledge of all that relates to man's posture in order that we may ascertain how far it is now necessary to modify, extend, or amplify Darwin's explanation of its evolution. My aim in this lecture is to pass in brief review recent inquiries and investigations which throw fresh light on how, when, and where man came by his erect attitude. I have also another object in view—to show that the problems relating to the evolution of posture have a very direct bearing on medical and surgical practice; many of the obscure and distressing conditions which require treatment are in reality manifestations of a disturbance or derangement of the elaborate mechanism which regulates and maintains the remarkable posture of the human body.

EVIDENCE FROM FOSSIL REMAINS.

The fossil remains of man, so far as they have become known to us in recent years, do not provide any certain clue as to the date, place, or manner in which the human posture was evolved. We cannot say that any fossil form of man yet discovered shows a foot in a stage intermediate to that of anthropoid and man. The most important discovery for our present purpose is that made by Dr. Eugène Dubois during 1891 and 1892 when he was resident in Java. He discovered the remains of a strange and distinct genus of man, to which he gave the name of *Pithecanthropus erectus*. No part of the foot, leg, or trunk was found, only three teeth, the roof of the skull, and the left thigh bone. The thigh bone leaves us in no doubt as to the posture of body; it is human in all its characters; we cannot explain its characters unless we suppose that Pithecanthropus was human in posture and gait. The stratum in which the remains of Pithecanthropus were found belongs either to the beginning of the geological epoch which precedes the present—the Pleistocene—or to the end of the still older epoch—the Pliocene. We thus know for certain that the human posture was fully evolved at least before the beginning of the Pleistocene period. There are many reasons, however, for supposing that Pithecanthropus represents a persistence of a primitive type which had appeared long before the beginning of the Pleistocene; in size of brain we must regard him as representative of man at the beginning rather than at the end of the Pliocene period. The thigh bones show that the lower extremities were used as in us, but the characters of the skull are incompatible with the poise of head seen in modern man. In the fossil man of Java the head was hafted to the neck as we see in living anthropoids—so that the head is carried with a forward slouch.

In recent years we have greatly extended our knowledge of that peculiar and extinct type of human being now known as Neanderthal man. The bones of the foot, leg, and thigh all show certain features which manifest a closer resemblance to the corresponding parts of the gorilla than do the same bones in modern man. The head was set on the neck in a manner which clearly represents a modification of the anthropoidal fixation. The earliest trace of Neanderthal man so far discovered is the Heidelberg or Mauer mandible, which was found in 1907 by the late Professor Otto Schoetensack in a stratum belonging to the older deposits of the glacial or Pleistocene period. The Heidelberg mandible clearly belongs to a very primitive type of Neanderthal man; the more humanized type became extinct long before the close of the Pleistocene period, and apparently long after men of the modern type had come into existence. There thus persisted into the Pleistocene period a race or species of man in which the body was less perfectly adapted for holding the head and body erect than is the case with modern man. Yet in the Pithdown type of man, who, in a geological sense, was the contemporary of Pithecanthropus, the head was carried almost as in modern Europeans. The conformation of his mastoid process and the muscular impressions of his occipital bone leave us in no doubt as regards this matter. Thus in recent geological periods there have been races or types of mankind showing degrees in their adaptation to the posture and gait of modern man.

A survey, then, of our present knowledge of extinct forms of man permits us to make only a guarded statement as regards the date and manner of the evolution of our posture and gait. It is apparent that the adaptations which permitted the head to be balanced on the neck are comparatively late acquisitions; they appear to have been evolved since the commencement of the Pleistocene period. The lower limbs assumed a human form at a much earlier date. Pithecanthropus had a fully evolved human femur, and we must infer that the foot was equally human. If I am right in regarding Pithecanthropus as representative of mankind at the beginning rather than at the end of the Pliocene, then it is in the strata of an older period, at least the Miocene, perhaps the Oligocene, that we must look for those ancestral forms which will show us the anthropoid foot and leg assuming the characters which we regard as human. "We are far," says Darwin, "from knowing how long it was since man first diverged from the Catarrhine stock, but it may have occurred at an epoch as remote as the Eocene period." We see, then, that Darwin was prepared to find fossil remains showing changes in the foot and leg such as I have just mentioned in even earlier formations than the Oligocene.

EVIDENCE FROM THE ANATOMY OF ANTHROPOIDS.

Having thus surveyed the evidence afforded by the fossil remains of man I propose now to inquire how far our present knowledge of the structure and habits of man's nearest allies—the anthropoid apes—will assist us in solving the problems of human posture. Our knowledge of these allies, both living and extinct, has greatly extended since Lamarck and Darwin formulated their theories, and we realize that both of these great men grossly underestimated the complexity of the problem and failed to realize that the structural adaptations which made plantigrade progression possible for man were not sudden transformations produced for man's particular benefit, but had come into existence during the evolution of the anthropoid body. It is in the evolution of the early anthropoids that we have to seek for the rise and development of the chief postural modifications of man's body. This truth was brought home to me very forcibly over thirty years ago when, as a medical officer and naturalist attached to a mining company exploring the mineral wealth of the Malay Peninsula and of Siam, I was drawn into a study of the apes and monkeys living in the jungles of these countries. They were regions in which malaria was endemic, and I set out to ascertain if the apes of the jungle suffered as much from fever as did the people of the villages. There were in my neighbourhood wandering troops of three kinds of ape, all of about the same size—weighing from 15 to 20 lb.: (1) the gibbon, the smallest and by far the most primitive of anthropoid apes; (2) various species of Semnopithecus, best known by their Indian cousin—the langur or holy monkey; (3) various species of the macaque monkey. My attention was soon transferred from the primary object of my investigation to the remarkable anatomical features of the gibbon's spine and trunk; in their arrangement the bones and muscles of the gibbon were altogether human, while the same parts in the semnopitheque and macaque, which outwardly looked as if they might be cousins to the gibbon, were altogether different. It was then I realized that the history of many of man's postural adaptations had to be traced back to the evolution of the gibbonish or hylobatian body (Hylobates is the generic name for the gibbons). Nor was there any difficulty in ascertaining that these structural features of the gibbon's body were postural adaptations. In his flight from tree to tree the gibbon's manner of progression differs altogether from that of monkeys. It is true that before starting their flight the resting posture of gibbon and monkey is much the same; both sit in a semi-erect posture, resting on their ischial callosities. In progression the gibbon uses his long arms as the chief means of support and of propulsion; he leaps with his arms; the lower limbs are deftly used as accessory means of support or as the chief means when running along horizontal branches. The body is held, in all movements, upright to the plane of progression. The gibbon is *orthograde* in its gait, whereas his neighbours, the monkeys, are *pronograde;* as they passed from branch to branch, or from tree to tree, their bodies are held parallel to the plane of motion. The semnopitheque was a heavy jumper; in a forward leap the impetus came from the hinder limbs and loins; the hands and arms were used to clutch the branch on

which he lighted, but were never used in the hand-over-hand method which is habitual in the gibbon—a true trapeze athlete. These early observations convinced me that if we are to seek for the beginnings of human posture we must first unravel the history of the gibbons.

The Evidence Afforded by Gibbons.

In point of structure the gibbon occupies a central position among the higher form of primates. It is linked to the three surviving great anthropoid apes—the gorilla, chimpanzee, and orang; all of these show a greater degree of adaptation than the gibbon to the orthograde posture. We have also good reason for believing that they are later in date of evolution. The gibbon, when allowance is made for its postural modifications, stands out as the cousin of old-world monkeys; all of these are pronograde in their gait, but in some the arms are used and developed to a much greater degree than in others; this is particularly true of those forms in which the tail has become reduced in length and strength. We shall see that the development of the tail depends on posture and gait. The gibbon is also cousin to the higher forms of South American monkeys; in some points of structure it is more nearly allied to them than to the monkeys of Asia and of Africa. The higher new world apes, although essentially pronograde in their gait, show a specialization of their hinder limbs, and in many cases a peculiar use of their tails, in grasping and climbing. While in the evolution of the gibbon the upper limbs have been exploited as means of support and progression, the specialization of function in South American monkeys has been concentrated on the lower limbs—they are used for suspension rather than for support. The structural similarity which unites gibbons, old-world monkeys, and new-world monkeys is such that we must regard all three as arising from a common ancestral form, from which has arisen a series of postural types represented in the small anthropoids and monkeys of the old and of the new world. The chief problem in the evolution of the gibbon, as of man, is the discovery of the machinery which Nature employs to mould structural form to postural function; the nature of this machinery we shall consider later. Meantime, so far as concerns the group of primates to which man belongs we may safely say that the greatest structural revolution which marks the history of this group occurred with the evolution of the gibbon. It is to this ancient structural revolution that man owes the chief of his postural modifications.

THE ANTIQUITY OF THE ORTHOGRADE POSTURE.

All the evidence at our disposal points to an ancient origin for the small anthropoids of the hylobatian or gibbon type. Fossil remains of them have been found in the Pliocene and Miocene deposits of Europe, and so like are they to the corresponding parts of modern gibbons that we feel certain that in the living gibbon we are dealing with an ancient and conservative type which has come through long geological epochs almost unchanged. It is highly probable that the orthograde gibbon and its pronograde cousins of the old and new worlds began to be differentiated towards the end of the Eocene period. In the Eocene formations of North America and of Europe are found fossil remains of numerous primates, but all of those so far discovered are tarsioid in form—more generalized in structure than gibbons or monkeys. The common stock from which gibbon and monkey arose will probably prove to be an Eocene tarsioid. That the orthograde hylobatian type had been differentiated from the ancestral pronograde monkey type at an early period is proved by the discovery of the remains of fossil apes in the Oligocene deposits of Egypt, which in point of geological age are intermediate to the older Eocene and more recent Miocene formations. Amongst these Egyptian fossil remains, which were described by Professor Schlosser in 1910, was the left half of a mandible of a small and primitive form of gibbon. Whether or not this early gibbon possessed the orthograde posture we have as yet no certain means of telling, but there is good reason for presuming that it did.

THE TROGLODYTE OR GREAT ANTHROPOID STAGE.

The first or hylobatian stage in the evolution of man's posture came during a remote geological epoch, with the appearance of the small type of anthropoid ape now represented by the gibbon. The second stage came with the evolution of the great anthropoid apes; and because the chimpanzee is the most generalized surviving member of this group and in former times was given the generic name of Troglodytes, this stage in the evolution of man's posture may be named the "Troglodytian." All available evidence points to the great anthropoids as having been evolved from a small anthropoid ancestry. In bulk and strength of body man and the chimpanzee are nearly alike, but the male orang, and particularly the male gorilla, outstrip the strongest man in strength and weight of body. With the evolution of the great anthropoids from the small, the weight of the body undergoing then an eight- or twelve-fold increase, adaptations for the orthograde posture and gait were necessarily modified as well as strengthened. In none of the great anthropoids do the arms reach the high degree of specialization in structure and function to be seen in modern gibbons; none of them are pure brachiators as are gibbons. In the orangs, it is true, the arms are much more important and more developed than the legs for arboreal progression; in the gorilla the opposite has happened; the lower limbs are the more specialized. The chimpanzee holds an intermediate position, both limbs being developed to an equal degree, as was probably the case in early anthropoid forms. One other point deserves mention; in the gibbon, as in old-world monkeys, there are ischial callosities to serve as natural rests in the sitting posture; in the great anthropoids these callosities have disappeared. As in man, true rest is obtained by the great anthropoids only when the body is laid prone upon bed or tree scaffold.

Such scanty evidence as we now possess leads us to believe that the troglodytian, or second, phase in the evolution of man's posture, took place about the end of the Oligocene period or the beginning of the Miocene. We know of the fossil remains of at least six species of Dryopithecus, an anthropoid which was neither less nor more primitive than any of the surviving giant anthropoids. The earliest traces of Dryopithecus come from deposits belonging to the middle of the Miocene period; it will probably be found that the great or giant form of anthropoid is pre-Miocene in date of origin.

THE THIRD OR PLANTIGRADE PHASE.

We come now to the third phase in the evolution of man's posture—the *plantigrade* stage. The first, or hylobatian, stage came with the appearance of the gibbons; the second, or troglodytian, with the evolution of the great anthropoids; and the third, the really human stage with which we are now dealing, when the line leading on to man branched off from the great anthropoid stock. The structural changes which occurred in the third stage were confined almost entirely to the lower limbs. The knees and thighs became more extended and strengthened until the lower limbs came to appear as if they were a downward continuation of the trunk. The pelvis or fulcrum of the lower limbs, as also of the spinal column, was modified; the hip and knee joints became adapted to the new posture; the muscles and bones of the leg assumed a human form; and, above all, the foot was transformed. We shall see, however, that underneath all that is so peculiarly human in our lower limbs there still lurk numerous vestiges and arrangements which we can only explain by supposing that at one time all the parts had passed through a troglodytian stage in their evolution. In the third stage only minor alterations occurred in the structure of the trunk. The chief adaptations to fit the thorax and the abdomen to the erect posture had been nearly perfected before the third or plantigrade stage had commenced.

In which geological period the third stage was entered and the plantigrade posture evolved we cannot as yet fix with any degree of certainty. No fossil form has yet been found in which the lower limbs are in process of transformation. It is true that the lower limbs of Neanderthal man show minor anthropoid traits, but it is also true that the femur of Pithecanthropus is a fully developed human form. No one who accepts evolution as a working hypothesis will have any difficulty in regarding the three great anthropoids—the gorilla, the chimpanzee, and the orang—as divergent branches from the common giant stem. Seeing that man shares so many characters in common with these we are compelled, I think, to regard man as an aberrant branch from the troglodytian stock or stem, and it is therefore probable that the plantigrade posture was evolved as soon as the common giant stock began to break up into its various living and fossil forms. We know for certain that this stock was in existence before the middle of the Miocene period, and it is therefore prior to that very remote date, most likely about the beginning of the Miocene or end of the Oligocene—two or three millions of years ago at the lowest estimate—that the plantigrade posture began to be evolved.

THE MODERN THEORY OF MAN'S POSTURE.

Thus it will be seen that modern anatomists no longer regard the postural adaptations of the human body as the result of a transformation peculiar to man, as did Lamarck and Darwin. They regard man's gait and posture as the culmination of a series of evolutionary phases which are to be traced in the bodies of orthograde primates throughout the greater part of the Tertiary duration of the earth's history.

THE COMPLEXITY OF THE PROBLEM.

The great extension of our knowledge of the constitution and mechanism of the central nerve system, largely the outcome of the discoveries made by Sir Charles Sherrington during the past thirty years, has shown us that the evolution of the orthograde posture was a far more complex and difficult problem than the great pioneers had supposed. We know how complex and delicately adjusted are the nerve centres which carry out the spinal reflexes of even pronograde apes; with the elaboration of the orthograde posture all of these spinal centres must have undergone a structural elaboration as well as a functional adjustment. Further, the orthograde posture, even in its more primitive form, demands a higher degree of co-ordination of the reflex centres in the spinal cord—centres or clusters which extend from one end of the cord to the other; consequently the higher centres—the red nucleus and other cell masses of the mid-brain, which regulate the postural tone—and the cerebellum, which has so much to do with the "timing" of the spinal centres, must have undergone a high degree of elaboration and expansion. The elaboration of the centres for automatic control of the orthograde muscular system was accompanied by an expansion of the basal ganglia and cortical centres of the brain. During the evolution of the orthograde posture brain and body had to become modified in unison.

The researches of Dr. Leonard Hill have made us aware of the elaborate mechanism needed to regulate the arterial blood pressure when the posture of the body is changed. In the early pronograde primates the vasomotor postural mechanisms must have been already highly evolved, but it is clear that, with each step towards the plantigrade posture of man, there must have been further specializations in the reflex centres which control the distribution of blood and in the structures which support the weight of the blood mass. Further, we shall see that all the structures concerned in the mechanism of respiration underwent a change in form, function, and control. The evolution of the orthograde posture entailed a structural revolution in all parts and systems of the body, from the crown of the head to the soles of the feet.

THE MACHINERY OF STRUCTURAL EVOLUTION.

When we see that a change from the pronograde to the orthograde posture entails a modification of nearly every muscle of the body as well as of corresponding changes in the nerve centres which control them we have to seek an answer to this problem: By what evolutionary machinery does Nature bring about simultaneous and harmonious modifications in a thousand apparently independent units of structure? The explanation offered by Lamarck, and also to a certain extent by Darwin, was that in the animal body there exists a mechanism by which structural modification acquired by one generation as the result of use and habit can be passed on, in ever-increasing degree, from generation to generation. The existence of such a machinery for transmission is not only unproved, but for several reasons is highly improbable. Darwin observed that there was evidence of some controlling factor which correlated the growth of associated structures. The nature of the mechanism which regulates the development and growth of parts and so fits them for performing their function in a new way is becoming apparent bit by bit as we get to know more of the behaviour of animal tissues. Phagocytes are attracted to sources of infection by a chemotactic mechanism. Kappers of Amsterdam has demonstrated that groups of developing nerve cells migrate in swarms and arrange themselves at sites favourable for the reception of the stimuli with which they have to deal; to the mechanism involved he gives the name "neurobiotaxis." Cells removed from the body of an embryo and grown in artificial media exert a regulating influence on each other; in a sutured wound of the intestine epithelium seeks out epithelium, and muscle cells seek out muscle cells in the process of union. The testicle throws into the blood a hormone which stimulates and regulates the growth of a crop of structures. In acromegaly we see a structural transformation effected in all systems of the body. It is along such lines as these that we are to be guided to the adaptational machinery which Nature has employed in bringing about evolutionary changes in posture and in the creation of new types of animals. We are only beginning to realize the elaborate growth machinery which is at work in shaping the body of the embryo; the one thing we can be certain of is that this machinery is constituted, not on an anatomical, but on a physiological basis. Further, it is not a supernatural machinery but one which, given means, opportunity, and industry, the mind of man can study and determine.

The Goulstonian Lectures

ON

THE NATURE OF ARTERIO-SCLEROSIS.

DELIVERED BEFORE THE ROYAL COLLEGE OF PHYSICIANS OF LONDON

BY

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[*With Special Plate.*]

LECTURE I.*

IN leaving £200 for the maintenance of these annual lectures, Dr. Theodore Goulston directed that a dead body should, if possible, be procured and two or more diseases treated of. Arterio-sclerosis, as it happens, fulfils both conditions, since it is largely based on *post-mortem* study and includes two or more diseases. It is too often depicted as a permanent pathological change, the final result of a process of arterial decay. There is a mark of finality about these structural changes in vessel walls due to the accidental circumstance of their being chiefly studied after death, due also in part to the degenerative changes being more obvious than the proliferative, and in part to arterio-sclerosis being more common in the old than the young; hence the discovery of these changes during life tends to be accepted as evidence of wear and tear significant of an irrevocable step towards the grave. It is my object to bring forward some facts that will give this slow process of arterial "decay" some vitality and life, for I think it can be shown to be a process of disease with an onset that as yet escapes clinical recognition, and a course in which arrest or recovery are commoner than death.

DEFINITION OF ARTERIO-SCLEROSIS.

The problem of arterio-sclerosis is faced at once by the difficulty of its definition. Osler[1] defined it as "a condition of thickening of the arterial coats, with degeneration, diffuse or circumscribed." This definition states the two essential criteria of arterio-sclerosis—namely, the new formation of tissue and the presence of degeneration; the word "thickening" is better than the word "hardening," which is often used, because it marks the new formation of tissue. Forms of both acute and chronic arterial disease with thickening of the arterial coats but without degenerative lesions are excluded by definition from arterio-sclerosis. Thus periarteritis nodosa, thrombo-angeitis obliterans of Leo Buerger,[17] intimal thickening in ligatured vessels, and the endarteritis of Friedländer,[18] in all of which thickening of the walls occurs characteristically without degenerative change, are excluded from arterio-sclerosis.

The definition, however, makes no reference to the nature of the underlying process nor to the problem of causation, and it is therefore too inclusive. In their definition of arterio-sclerosis Thorel[2] and Marchand[3] take into account the underlying process, and in addition to emphasizing the importance of intimal thickening refer to "degenerative changes, inflammatory and productive processes" (Marchand), while Thorel speaks of "hyperplastic changes, and perhaps also inflammatory proliferation." In the second place, arterial lesions whose causation is known, even if they show both thickening and degeneration, do not belong to arterio-sclerosis, but are placed under their specific title. Thus syphilitic mesaortitis, and syphilitic and tuberculous endarteritis do not belong to the group of arterio-sclerosis, though syphilis may have to be taken into account as a factor in the causation of arterio-sclerosis when the anatomical lesion is that of arterio-sclerosis and the possibility of its being syphilitic is suspected but not assured.

* Abstract of lecture delivered on March 6th.